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ORIGINAL ARTICLES.

I.—Four and a half Months in Crete in search of Pleistocene Mammalian Remains.

By Dorothea M. A. Bate.

(PLATES IX AND X.)

THE geological map of Crete shows that a large portion of the island is composed of ancient limestone, in itself almost a guarantee of the presence of Pleistocene cave deposits. In confirmation of this, Admiral Spratt in his most valuable work[1] mentions finding two such deposits, from one of which he obtained a few mammalian remains.

I arrived off Khania early one morning in the beginning of March, 1904. From the sea the town is picturesque, being built down to the water's edge and almost encircling its tiny harbour. At some distance inland the Aspro Vouno rise abruptly in places to a height of 8,000 feet; this massive ridge forms the backbone of the western district, the wildest and most rugged part of mountainous Crete. At this time of year the snow lies for a considerable distance below the topmost summits, and it is not until months later that it disappears, leaving, as on Ida, a few patches on sheltered slopes and in deep crevices, where it remains the whole year round.

Roughly speaking, Crete may be said to consist of a high and central limestone ridge, at the foot of which is a border of fertile country. In three places this fertile zone extends across the entire width of the island, separating this backbone into four more or less isolated masses. These are the Aspro Vouno and the Mount Ida group, which are more closely connected than the other divisions, the Lassethe Mountains and the hilly plateau of Sitaea. It is curious to note that differences exist, both in language and dress, between

[1] "Travels and Researches in Crete," 2 vols.; London, 1865.

the inhabitants of these several parts of the island. The limestone formation reappears as a somewhat broken fringe along the coast-line round almost the entire island. In early days these limestone mountains and hills existed as a group of islands set in a Neogene sea, represented nowadays by the low and cultivated areas.[1]

Western Crete.

Khania being my headquarters, excursions were made to various places in the near vicinity, including Akrotiri, a peninsula of considerable size edged with limestone cliffs, which at its north-eastern extremity attain to a considerable height. This is more especially the case between Cape Tripiti and the village of Khoridaki, above which rises a hill of 1,745 feet; the cliffs descend almost perpendicularly to the sea, and in a few places are pierced by narrow, winding gorges. A good deal of this tract of country was examined at different times, and the results will be noticed here.

The first deposit found is believed to be the one mentioned by Admiral Spratt[2] between Khania and Suda. It lies close to the pathway between these two places, and at the edge of the limestone forming the base of the Akrotiri at the point where it joins the fertile plain of Khania, by which it is separated from the outlying spurs of the Aspro Vouno. The limestone is very much weathered, and only in one spot is there any roof above the fragmentary mammalian remains still to be seen. These occur here and there for a distance of about 40 yards, and appeared to consist chiefly of bones of a ruminant. Besides this some fragments of breccia were obtained which contained bones and teeth of some small rodents and of a shrew.

Raulin,[3] quoting from Pococke, describes the ruined village of Saint George, in the Akrotiri, in which there was a church built in a double-chambered cave said to contain petrified bones "plus gros qu'à l'ordinaire," this traveller himself seeing some in the softer parts of the rock in the outer chamber. It was a long time before this deserted village was found, it being now almost forgotten by the peasants of the district. I was eventually guided to it by a man from Khoraphakia, to whom it was known as Galagatho. It lies concealed among the hills at the back of the ridge rising above Cape Tripiti, and is reached by an extremely rough path, which most of the way is also the rocky bed of a mountain torrent. The ruins of the chapel are still to be seen; though of the inner cave of which Pococke speaks, but did not visit, no trace was observed. The floor of the single chamber is littered with dirt and rubbish owing to its being occasionally inhabited during the winter by shepherds and their flocks. In spite of this a few scattered fragments of teeth and horns of ruminants could be seen adhering to the base of the walls of the cave.

[1] See Spratt, op. cit., vol. ii, pp. 58–59.
[2] Op. cit., vol. ii, p. 195.
[3] "Descrip. Physique de l'Ile de Crete," p. 373; Paris, 1869.

A few days after arriving in Crete I rode out to the monastery of Haghios Joannes in the hills beyond the rich and important monastery of Haghia Triadha. Thence I walked down to the ruined and deserted monastery of Katholiko, or Gouvernente, near which is a cave which penetrates the side of the hill for a considerable distance. A visit was also paid to the well-known Cave of the Badger,[1] situated between the ruined monastery and that of Haghios Joannes. This has a tiny chapel and garden at its entrance, and consists of one large roomy chamber with a lofty roof. It contains a remarkable tank naturally enclosed by stalagmite which rises about eight or ten feet above the floor; for a great part of the year this is kept filled with delicious cold water which drips from a large stalactite hanging from the roof. No traces of an ossiferous deposit were found in either of these two caverns, and all enquiries for others in the district were met by the negative, this being all the more unfortunate as it caused me to cease investigations in the immediate vicinity.

It was not until the middle of July that I was shown and bought from a man near Khania a small elephant tooth about which he could, or would, give no information, except that it came from the Akrotiri. After several fruitless expeditions a villager interrogated at Khoridaki declared he knew of some petrified bones near the sea. Joining him a couple of days later (the 22nd) I was guided by a lonely hill path to Haghios Joannes, passing on the way the crumbling ruins of an ancient monastery. The ponies being left in the cave of Arkoudhes we walked down the hillside to Katholiko, which is situated at the head of a precipitous-sided and narrow, winding gorge. From here a scramble landed us in the dry stream-bed below, which was followed to the sea. Then turning to the left along the rocks at the foot of the cliffs a spot was soon reached where a few fragments of bone were found still adhering to the much weathered rock; these no doubt indicate the position of a former cave deposit, but otherwise are of little interest.

Returning to the mouth of the gorge, where my guide refreshed himself at a spring of mineral water much appreciated by the natives, I was about to retrace my steps, when a shepherd who had lately joined us volunteered to show me another deposit lying in the opposite direction. He led us over very rough ground towards Cape Maleka, just before reaching which we halted where the rocks and overlying débris slope steeply down to the sea from within a short distance of the top of the cliffs. This proved to be the site of the deposit of which I was in search, and which is only a few yards above the sea. No trace is left of the former cave walls, while the ossiferous deposit has been largely destroyed, though, judging from the fragmentary portions that remain, it must originally have been of considerable extent. It being then late in the afternoon a return was made the following day, when several portions of molars and a fragment of a tusk of a pigmy elephant were with

[1] Or 'bear,' as it is sometimes translated. In this case the word used is 'arkoudhes,' though the name usually employed in the island for badger is 'arkalos.'

difficulty detached from the hard substance in which they were embedded. Besides these some pieces of breccia containing the remains of small rodents were also procured. Unfortunately it was only possible to work here for a few hours, for, owing to the distance and rough track, it occupied four hours each way to and from Khania. The fact that this was the only deposit in which traces of a dwarf elephant were observed made it a matter of much regret that the investigations begun here could not be continued, but it was impossible to delay my departure from Crete beyond the 24th of the month.

The first trip into the country from Khania took me to the monastery of Gonia, near Kolymbari, which was reached on March 20th after a ride of several hours, chiefly along the seashore. The following morning no difficulty was experienced in finding the cave (Plate IX) already described by Admiral Spratt,[1] who obtained from it a few remains which he mentions as having been identified by Dr. H. Falconer[2] as those of "a goat, a roebuck, or stag, and of a small *Myoxus*." For several days some work was carried on here, but without much success, for the ossiferous deposit, which was very hard, extended only a little way inside the cave, and specimens worth preserving were difficult to obtain. A number of other caves on this side of the peninsula, including the Kimido Spilia of the Admiralty Chart, were examined, but without result.

Later, when staying at the tiny village of Kamara Kumuli, I was taken to a small cave or hole in the cliffs below, and somewhat to the south-west of Ravduka. In spite of the stalagmitic flooring of what remained of this cave being entirely broken up, presumably by the action of the waves, some few good specimens were obtained from a crevice half-filled with earth and sand. A portion of the bone breccia could be seen to extend for a short distance below the present level of the sea. The remains noticed here included only those of the two species of ruminants already mentioned.

On a trip to Malathiros, which lies some little distance in the hills inland, no bone caves were heard of, but more success attended a return to the coast still further west. At the western base of the Grabusa Akrotiri lies the small promontory of Kutri, or Phalasarna, to give it its ancient name, the site of the western town of the early civilization of Crete.[3] At the northern edge of this cape, where the limestone cliffs are reduced to an insignificant height, a cave opening towards the sea was found to contain the remains of a large ossiferous deposit. That this must originally have been of considerable extent is shown by the fact that between the highest and lowest traces of bones is a distance of fifteen feet; these probably occurred in bands of about three feet in thickness and separated by layers of stalagmite. Two such bands were clearly traced at the inner end of the cave; in the upper remains of an

[1] Op. cit., vol. ii, pp. 194–5.

[2] I have been unable to find any account of these remains published by Dr. Falconer.

[3] Spratt, op. cit., vol. ii, chap. xix.

antelope were most plentiful, while in a lower one horns and teeth of a deer predominated.

In the cliffs less than a hundred yards to the south-west is another cave which can only be reached from the sea. This is smaller and narrower than the one described above, and contains only a very fragmentary remnant of an accumulation of mammalian remains. Besides this some few specimens were brought in by one of my men, who said he had procured them from a cave on the east coast of the Grabusa promontory and about two hours walk from Kalivjannee, but I was unable to go and verify this information. Previously, when at the eastern base of this Akrotiri, a great number of fossilised remains of a large echinoderm were noticed in the low sea-cliffs at this spot.

Before leaving Mesoghia,[1] whence the Kutri cave was worked, a visit was paid to Sphinari on the coast at some hours distance to the south. Its position is somewhat isolated, and it is claimed by the inhabitants to be an outlying village of the Enneakhoria. A walk of less than an hour along the cliffs on the south side of the small bay brought us to the partially submerged remains of a cave deposit, now almost entirely destroyed. Of the cave itself this is the only trace to be seen; some teeth and bones of ruminants and part of the dentition of a rodent were obtained here.

No other deposits were found west of Khania, but before describing those discovered in the east of the island a few remarks on the former may not be out of place. Apart from the interest of the mammalian remains contained in them the situation and condition of these deposits suggest a number of problems as to the probable method of their origin, to which it seems difficult to supply any satisfactory explanation. The Kutri cave may be noticed with more detail, presenting as it does phenomena somewhat similar to the smaller Kutri cave, that near Ravduka, and the deposit close to Sphinari. The lowest trace of bones is only about 10 feet above the sea, while the whole floor bears unmistakable traces of having been largely broken up and to a great extent washed away. On the walls of the cave is a distinct sea-level mark now about 20 feet above the water. In confirmation of this it seems to have been satisfactorily proved by the observations of Admiral Spratt[2] that a local[3] "déplacement negatif" to the extent of 22 feet has taken place at this point of the coast, and that *within historical times*, making it a matter of certainty that this has occurred since the accumulation of the ossiferous deposit.[4] A similar alteration of the

[1] This is an isolated homestead which, although close to Kalivjannee, is called Mesoghia, no doubt after the villages of that name to which it probably belongs.

[2] Op. cit., vol. ii, chap. xix, pp. 195–6, etc. Suess also gives a list of records in this connection: see "La Face de la Terre," vol. ii, pp. 700–1 and 740.

[3] That this was only local is proved by the fact that in the east of the island a contrary movement has occurred also within historic times. See Spratt, op. cit., vol. ii, pp. 21–2, etc., and Suess, op. cit., vol. ii, pp. 700–1.

[4] Admiral Spratt even says in discussing the disappearance of the harbour at Tripiti, on the south coast, which was described by the author of the "Stadiasmus," that this is "another proof of the great upheaval along the coast having taken place since a late Roman period, the date of the 'Stadiasmus' being considered to be about that time" (op. cit., vol. ii, p. 246).

coastline, though in a greater or less degree, is recorded by this author for nearly the whole of the west coast of Crete.

It might be assumed that the ossiferous remains were introduced into the cave by the sea, but on the other hand several facts seem to suggest a different explanation. The appearance of the interior of the cave points conclusively to its having been invaded by the sea subsequently to the deposition of the mammalian remains as already mentioned above. The material in which these are embedded is exactly similar to that found in other caves differently situated, and does not contain sea shells, though a few occurred, together with a small quantity of sand, in a hole or crevice. Some of these were adhering to pieces of bone which were exposed at this spot, but none were found enclosed in the solid matrix in conjunction with the mammalian remains. A considerable quantity of coarse sand was also observed in a crevice containing a number of remains in the cave near Ravduka.

As an alternative the only manner in which it seems at all possible that these remains could have been deposited in the caves when under water would be through the agency of an underground river with its outlet below the surface of the sea. Accumulations might then have formed in a backwater or eddy, or even in the main stream when it had become sufficiently reduced to allow of this. The partial destruction of the deposits by sea action would take place when the sea and cave eventually occupied relative positions that would allow the surf to break in with some force. In Crete, as in other limestone countries, these subterranean streams are by no means uncommon;[1] as examples mention may be made of the swallow-holes, locally known as khonos or katavothron, which carry off the waters from a number of hill-encircled upland basins. Besides these are several streams with a large flow of water which abruptly rise out of the ground, as near Haghios Nikola, at Armyro west of Candia, and at Armyro on the coast at the south-west corner of Armyro Bay.

On the whole it seems easier to believe that these bone breccias were originally formed on the floors of land caves subsequently submerged beneath the sea, from which they have again been gradually elevated to the extent already noted.

To account for the disappearance of the walls and roof of some of these caves, such as at the deposit near Cape Maleka and several others in the east of the island which have not been submerged, is not difficult. For even where the action of the sea has played no part, or only to the extent of surf breaking in during storms, the effects of weathering on these practically barren limestone rocks is very rapid and severe. As a factor of possible importance in the destruction of the caves, it may be remembered that Crete lies within the zone where earthquakes are of by no means infrequent occurrence; a particularly severe one doing much damage to many of the towns occurred as late as 1856.

[1] An interesting paper dealing with this subject is "Submarine Gullies, River Outlets, and Fresh-water Escapes beneath the Sea-level," by H. Benest, Assoc. M. Inst. C. E.: Geog. Journal, October, 1899, vol. xiv, pp. 394–413.

Eastern Crete.

In the beginning of May, shortly after returning to Khania from a second trip in the west, a start was made for the east, where I remained until shortly before leaving the island in the latter end of July. Candia was reached, after a somewhat wandering course, including Lake Kurnas, Myrthio (from whence one of the small beds of fossil wood mentioned by Raulin [1] was visited), Kria Vrisis, Phaestos, and Haghia Deka, near which is the enormous underground quarry known as the Labyrinth.

Along the coastline east of Candia no cave deposit was found until Melato, in the eparkhia of Mirabello, was reached. Here one was discovered on the bare hillside to the north-west of the village, and between it and the sea. No part of the former cave was to be seen except a few fragmentary portions of the stalagmitic flooring showing above the ground, and containing remains of a pigmy hippopotamus.

To the east of this my wanderings were continued through the fertile plain of Mirabello, and on by a road never very far from the coast to Sitaea. Thence to the monastery of Toplou, Eremopoli, with its ancient ruins, and Palaikastro, the site of important archæological excavations made under the auspices of the British School of Athens. A return was made across the limestone plateau in which Khandra is situated, by Daphnaes and Rhukaka, down the gorge to Kavusi, where the former route was joined.

The only cave deposits found in this part of the island were situated in the rugged limestone cliffs bordering the southern end of the Bay of Kharoumes, not many miles south of Palaikastro. At the foot of these cliffs and only from a few feet to a few yards above the sea were discovered one small bone cave and, on either side, portions of the stalagmitic flooring of two others; all being situated close together and extending for a distance of about a hundred and fifty yards. The most northerly of these deposits, which is at a greater height than, and at a little distance from, the cave, contained only bones and teeth of the small hippopotamus which also occurs at Melato. The remains in the cave and in the other deposit [2] proved to be those of ruminants similar to those found in the caves of the west of the island.[3]

Some little distance further along the coast in a south-easterly direction is another cave, in which the floor is entirely broken up and heaped with huge boulders; at its inner end, however, a few bones and a piece of a deer's horn were observed. These were embedded in the roof, which at this spot is partly composed of red earth. The position of these remains seems to be a strong argument in favour of the idea that, at all events in this instance, they must

[1] Op. cit., vol. i, p. 181, and Spratt, op. cit., vol. ii, pp. 270–1.

[2] A few land-shells were obtained here, and have been identified by the Rev. R. Ashington Bullen as *Helix pellita*, Fer.

[3] A few fragmentary remains of a large proboscidian were found in the rocks close to this cave. They have not yet been examined, but will probably prove to be of earlier age than Pleistocene.

have been introduced through the agency of water. The same was probably also the case in the other cave close by, in which it can be seen that, previous to the stalagmitic flooring having been disturbed, part of the bone breccia had reached to within about a foot of the roof, and this in the portion of the cave where the present entrance is situated. A curious point in connection with, though perhaps hardly in support of, this theory is that the different species were not found indiscriminately mixed together in any one deposit. The remains of the antelope and deer seem to be invariably associated, though the proportions in which they occur may vary in the different layers of the floor, as in the Kutri cave (p. 196). Bones and teeth of small rodents were, in one or two cases, found in the same deposit as the above; similarly they occurred in a fragmentary portion of the upper layer of the breccia near Cape Maleka, which besides these only contained remains of a pigmy elephant. Further, no other species was observed in either of the two cave deposits in which portions of a dwarf species of hippopotamus were found, although one of these, as already mentioned, was situated only a few yards from a cave containing remains of ruminants.

As long ago as about the year 1842[1] some remains of a small hippopotamus were obtained at Candia by Captain Graves, R.N., though it was not known where they came from. Somewhat later further specimens were procured at Kritsa, a large village on the eastern base of the Lassethe Mountains, by M. Raulin,[2] who was told that they had been found in the upland basin of Katharo. This spot he visited, and subsequently described, but without finding any specimens in the deposits in which they were said to occur. Owing to this information Kritsa was visited at the earliest opportunity, and here a small number of isolated hippopotamus teeth were brought in by the villagers, and at length an old man appeared who professed to know the locality from which they came. The following day he took us to the upland basin of Katharo, which is about three hours from Kritsa and nearly 4,000 feet above the sea. Although already past the middle of May, at this height it was bitterly cold, a keen wind bringing with it a damp and all-enveloping fog. This spot is not permanently inhabited, only a few shepherds staying here with their flocks during the summer months, when they and their beasts obtain shelter in rudely built and indescribably filthy hovels; the only other buildings being one or two small dedicatory chapels. A few crops of corn and vetches struggle for existence, while a number of fruit-trees grow in shelter of the northern hills. This mountain valley runs almost due east and west, and is about two miles long and from half to three-quarters of a mile wide. Completely encircled by hills, its surface presents an undulating appearance, particularly at its eastern extremity, and it is intersected by a number of streams all flowing westward, in accordance with the general inclination of the valley. These have

[1] Spratt, op. cit., vol. ii, p. 386.
[2] Ibid., pp. 386–7.

excavated their courses in places to a depth of eight or ten feet, showing that the ground to this extent consists of reddish yellow and grey clays topped by a layer of darker soil varying in thickness from a couple of inches to one and a half or two feet. At the western extremity of Katharo, where the hills are lowest, the streams have broken through the rocky barrier, cutting a deep and narrow gorge by which the accumulated waters find a way to the more extensive upland basin of Lassethe, which lies nearly a thousand feet below.

My guide first took me to the top of a rounded hillock in the eastern half of the valley, where a few fragmentary remains were found lying on the surface, where some débris evidently of volcanic origin, such as lava, etc., was also observed. During the next few days trial trenches were dug in a number of places in this vicinity, teeth and bones of a pigmy hippopotamus being found in varying quantities and at different depths. At the spot shown in the photograph (Plate X) the remains occurred somewhat sparingly in a band of bluish grey clay about one and a half to two feet thick. In a channel cut by a stream through yellowish clay others were found in great numbers at a depth of six to eight feet below the surface. Here the infiltration of water made them very rotten and difficult to extricate intact; however, eventually a number of teeth and jaws and a large series of perfect limb bones were obtained.

The presence of these hippopotamus remains shows that the deposit in which they occur is almost certainly of fresh-water origin, and this is easy to believe when it is remembered that before a channel was worn through the barrier of surrounding hills there was probably no outlet for the accumulated waters, which in that case would transform the valley into a lake or swamp, according to the season of the year. A view of the neighbouring enclosed plain of Lassethe encourages this idea, for here the only egress for the streams is by means of a swallow-hole, or khonos; should anything cause this to become blocked the drainage of both Katharo and Lassethe would be forced to remain in the latter, soon forming it into a marsh and possibly a lake after the melting of the snow off the surrounding mountains. Admiral Spratt mentions [1] that in spite of a swallow-hole in the upland basin of Omalo, in the Aspro Vouno, the centre of it is converted into a lake for some months during the winter.

Considering the ordinary habitat of the hippopotamus, it is curious to find numerous remains of a small species at the unusual height of nearly 4,000 feet above sea-level, and that amongst rugged and barren mountains. The above-mentioned author considered [2] that their occurrence in this situation "involves the necessity of conceiving great physical changes in the relative levels of sea and land since they existed in Crete." His suggestion of a depression in this part of the island to the extent of some 3,500 feet would seem

[1] Op. cit., vol. ii, p. 176.
[2] Ibid., p. 387.

to be disproved by the discovery of similar, and presumably contemporary, remains nearly 4,000 feet below Katharo. May it not be that this upland basin, then a lake or marsh, became a last stronghold of a dying race of hippopotamus? This does not seem so improbable if we imagine a slightly warmer climate to have been then prevailing, and with it the consequent existence of a vastly greater amount of vegetation.

Conclusion.—It will be seen from the above that during my stay in Crete thirteen deposits containing remains of Pleistocene mammals were found, though only four were worked to any extent. These are all situated in the northern half of the island, for it was found impossible in this time to explore more than a comparatively small area, and that imperfectly; the southern coastline was practically unvisited. This was partly due to the distances to be traversed and the slow rate of progress over rough country; the total disappearance in many cases of all traces of the caves save a portion of the stalagmitic flooring greatly added to the difficulties of their discovery.

The following is a list of Pleistocene ossiferous deposits found:—

1. Cave deposit near Sphinari, West Crete. (p. 197.)
2. Cave, Cape Kutri, West Crete. (p. 196.)
3. Cave, Cape Kutri, West Crete. (p. 197.)
4. Haghios Basilis (cave), near Ravduka, West Crete. (p. 196.)
5. Tripiti cave, near Gonia Monastery, West Crete. (p. 194.)
6. Cave between Khania and Suda, West Crete. (p. 194.)
7. Cave at Haghios Georgios, Khania Akrotiri, West Crete. (p. 194.)
8. Cave deposit below Katholiko Monastery, West Crete. (p. 195.)
9. Cave deposit near Cape Maleka, West Crete. (p. 195.)
10. Cave deposit near Melato, Mirabello, East Crete. (p. 199.)
11. Cave deposit (?), Kharoumes Bay, Sitaea, East Crete. (p. 199.)
12. Cave, Kharoumes Bay, Sitaea, East Crete. (p. 199.)
13. Fresh-water deposit, Katharo, Lassethe Mountains, East Crete. (p. 201.)

The mammalian remains found in the above have not yet been specifically determined, but are known to include the following: antelope, deer, elephant, hippopotamus, shrew (*Crocidura*), and at least two small species of rodents. Of these the elephant and hippopotamus represent dwarfed races, whilst the antelope will probably be found to belong to a hitherto undescribed form. It is hoped that it will be possible before very long to publish a detailed account of these remains. I take this opportunity to express my sincere appreciation of all the help and encouragement I received from many kind friends both at home and in Crete.

EXPLANATION OF PLATES.

Plate IX.—Tripiti Cave, near Gonia Monastery, West Crete.[1]

Plate X.—Men at work in the upland basin of Katharo, Lassethe Mountains, East Crete.

[1] Ossiferous remains occur in the cliff-face immediately below the mouth of this cave, as well as inside (see Spratt, op. cit., vol. ii, p. 195).

Men at work in the upland basin of Katharo, Lassethe Mountains, East Crete.

II.—Notes on British Dinosaurs. Part I: *Hypsilophodon*.

By Dr. Francis Baron Nopcsa.

(WITH A PAGE-ILLUSTRATION.)

DURING a recent stay in London the kindness of Dr. A. S. Woodward enabled me to study some of the splendid Dinosaurian remains in the British Museum.

Having principally occupied myself till now with Ornithopodous Dinosaurs, first of all *Hypsilophodon* attracted my attention, and my expectation that this type would prove to be the clue for the understanding of all the other Orthopoda has been perfectly fulfilled.

Hypsilophodon was described and figured at various times by Owen, Huxley, and Hulke; a restoration of this animal was given by Marsh in the Geological Magazine for 1896 (p. 6, Fig. 2), and the complete bibliographical list concerning this Dinosaur is compiled in my paper "Synopsis und Abstammung der Dinosaurier" (*Földtani Közlöny*, 1901, Budapest).

In consequence of our more recent knowledge of Dinosaurs in general I managed to detect some new points of remarkable interest.

Mandible. What Hulke, in describing the *Hypsilophodon* skull, No. 110, supposed to be the parietal, frontal, and post-frontal bones (Phil. Trans., 1882, pl. lxxi, fig. 1, *pa.*, *fr.*, *ps.f.*), turned out to be the outer view of a complete right mandibular ramus, so that the parietal changes into an articular, the frontal becomes the dentary, and the post-frontal the coronoid bone. This piece (p. 207, Fig. 4) is, in fact, the finest mandibulum of *Hypsilophodon* I have seen in the whole collection, and as such worthy to be refigured.

The general outline of the mandibulum, with its strongly abbreviated post-coronoidal part and its blunt processus coronoideum, reminds one somewhat of the under jaw of *Placodus gigas*, though it differs of course in nearly every detail, being built up after the *Iguanodon* type. The comparatively very slight elevation of the blunt coronoideum, a feature in which *Hypsilophodon* differs from *Iguanodon* and the Hadrosauridæ, is to be met with in the Upper Cretaceous *Mochlodon*, while the abbreviation of the post-coronoidal part of the lower jaw is a character which among all Dinosaurs is only known in the *Iguanodon* type.

So-called sclerotic plates. After fixing former differences of interpretation Hulke's so-called sclerotic plates were closely examined, and proved to be nothing else but the teeth belonging to the very same mandible, showing each a nicely polished masticating surface; the pointed projection on each of these so-called sclerotic plates being simply due to the median ridge projecting on the inner enamelled surface of each tooth (compare my similar figure of the masticating surface in *Mochlodon* teeth figured in my paper on *Mochlodon* in the Denkschr. d. k. Akad. Wiss., Vienna, 1901, pl. ii, fig. 11).

Basi-occipital bone. Another point of great interest not yet duly noticed in the skull of *Hypsilophodon* is the shape of the *bird-like* basi-occipital bone (Fig. 1, *bo.*). It is utterly unlike the same

bone in *Camptosaurus, Mochlodon, Iguanodon,* or *Telmatosaurus,* but rather reminding one of the *Compsognathus* or *Thecodontosaurus* type; and the *downward* direction of the foramina by which the cranial nerves pass out from the brain-cavity along the basal and lateral elements of the skull is an especially bird-like feature. Describing the basi-occipital and basi-sphenoidal elements in *Mochlodon,* I stated these elements in *Gresslyosaurus* are in the same relation to the same parts in *Zanclodon* as are those of *Mochlodon* to *Telmatosaurus,* and thus I could distinguish a *Mochlodon - Gresslyosaurus* or elongated and a *Telmatosaurus-Zanclodon* or abbreviated type. To this now a third type, the *Hypsilophodon-Thecodontosaurus* or bird-like type has to be added. The great phylogenetic and physiologic value of this fact, throwing much light on the relationship of Dinosaurs and birds and also on Dinosaur evolution itself, will be more fully explained on some other occasion.

Supra-occipital bone (p. 207, Fig. 2). As it has some years ago been doubted by Professor Koken that in Ornithopodidæ the supra-occipital enters into the foramen magnum (Neues Jahrb. f. Min. Geol. u. Pal., 1901, vol. i), it seemed desirable to settle also this question, and therefore a drawing of this part of another *Hypsilophodon* skull is also given. It will be seen at once that the supra-occipital contributes largely to the boundary of the wide foramen magnum, and that it rises very much in the same way as in *Hatteria* or *Compsognathus,* forming at the same time a sharp median posterior crest. The differences from the *Acanthopholis* or even the *Iguanodon* type are easily noticed. The processus parotici are not raised as in *Telmatosaurus,* but at the same level as the foramen magnum, and, showing at once where the missing squamosals are to be sought for, this indicates that the quadrate bone was *comparatively* short, that the superior temporal openings were visible from the side, and proves the presence of large hypoparotic fossæ.

Predentary. Although this bone is of quite exceptional interest, and was already described by Hulke in his monograph on *Hypsilophodon,* yet it never has been figured. *Hypsilophodon* is, as far as we know, the single Dinosaur in which a tooth bearing a præmaxillary comes to bear down on a predentary bone, and this is the reason why in p. 207, Fig. 3, an enlarged drawing of this element is given.

Dollo remarked some years ago that a toothed præmaxillary might well correspond to a tooth-bearing predentary, and I perfectly agree with the famous Belgian professor that this is exactly the thing one ought to expect if the predentary of the Orthopoda were an entodermal ossification and homologous with the same bone in *Aspidorhynchus, Amphignathodon,* or in human anatomy.

Working along quite other lines of research than Professor Dollo, I, however, recently came to the result that the predentary of Orthopoda cannot have been derived from a cartilaginous source, but must simply be regarded as a dermal ossification (Denksch. Akad., Vienna, 1904). The paradoxical fact that in *Hypsilophodon* an edentulous predentary meets a toothed præmaxillary is, as far as

I am aware, the best evidence that can be brought forward in favour of the newer interpretation. A comparison of this predentary bone with the one of *Mochlodon* and other Predentata, as figured in my third paper on Transylvanian Dinosaurs, is equally interesting, and the gradual prolongation of this bone along the line *Camptosaurus*, *Telmatosaurus*, and *Trachodon* may perhaps be termed as a sort of dolichocephaly due to the cursorial habits of these Phytophagous reptiles.

Præmaxillary. No doubt has hitherto been expressed regarding the statement that the front part of the jaw in *Iguanodon* was covered with a horny beak, and therefore an examination of the tooth-bearing præmaxillary in *Hypsilophodon* was also one of the tasks that had to be accomplished.

On the top of the well-preserved præmaxillary of one skull (Hulke, 1882, pl. lxxi, fig. 1), soon a small but pronounced rugosity was detected, and it was at once highly suggestive that this might be the place whence that dermal ossification originated which, spreading by and by over the whole præmaxillary, gradually formed the beak of the Orthopodous Dinosaurs and suppressed the function of some teeth. That this beak did, however, not yet act effectively in *Hypsilophodon* is, I think, proved by the presence of the well-developed præmaxillary teeth. As placed on the front part of the præmaxillary the rugosity mentioned is at the same time exactly on the place where in some reptiles and birds the *Eischwiele* of the German author appears, and the idea that this is more then a mere coincidence is perhaps not to be disregarded altogether.

Dermal ossifications (armour). Contrary to what we know of *Iguanodon*, *Hypsilophodon* was surely clad with a thin but a well-developed dermal armour, consisting of comparatively large yet thin and flat, feebly punctured bony plates. I managed, at least, to detect in more than one specimen some plates always showing the same sort of feebly grooved sculpture, and never referable to any part of the endoskeleton itself. A good sketch of such plates is given in one of Hulke's figures, and in p. 207, Fig. 4, of this paper the grooved markings also come out pretty well. This dermal armour is, again, a character in which *Hypsilophodon* approaches more closely the armour-clad Stegosaurs and Ceratopsia than any other Ornithopodous Dinosaurs.

Ossified dorsocaudal tendons. The first figure of ossified dorsocaudal tendons in a Dinosaur dates back to the year 1849, and is a figure representing parts of the tail of *Hylæosaurus*. Later on the same elements were mentioned by the Rev. W. Fox in *Polacanthus* (*Illustrated London News*, 1865). Again, in 1882 a figure and a short remark on these curious objects was given by Hulke in his *Hypsilophodon* paper, and in 1887 they were refigured very clearly in his paper on *Polacanthus*. In the same year (1887) came finally L. Dollo's paper mentioning them in *Iguanodon* and dealing with their physiological value. Thus ossified dorsal tendons are present in all the British Prædentate reptiles, with the sole exception of the

Liassic *Scelidosaurus*. It is to be remarked that (1) the rhomboidal arrangement of these tendons described in *Iguanodon* seems to be absent in *Hypsilophodon* as well as in the North American *Claosaurus*; (2) that in *Iguanodon* these ossifications are *absent* under the diapophysis, while in *Hypsilophodon* they are present also on this place, and form thus on each side of the tail two bundles which run along the neurapophyses and the chevron bones. Besides this the ossified tendons attain in *Iguanodon* their maximum of development in the lumbar region, while in *Hypsilophodon* their number augments the nearer we approach the end of the tail, so that this region is *entirely* ensheathed. The physiological value of such a rigid organ, already unexplainable in *Iguanodon*, becomes in consequence entirely a puzzle.

Fourth trochanter. Though the fourth trochanter of *Hypsilophodon* was already well figured and described by Hulke, I still feel induced to mention also this part, since Hulke in the *Neues Jahrbuch für Mineralogie* expressed some time ago his doubts about the correctness of my assertion that the 'trochanter pendant' represents a more primitive stage in evolution than the 'trochanter en crête.' Now I find that the trochanter pendant of *Hypsilophodon* just seems to prove the correctness of my original view. In *Hypsilophodon* the fourth trochanter is comparatively much broader than in *Camptosaurus*, where it also shows the pendant type, and in the Wealden *Iguanodon*, again, it is much more developed than in *Trachodon*, of the Belly River and Laramie Series. Comparing this fact with the development of the teeth in these animals, we find that the more complex development of the teeth runs parallel with the diminution of the fourth trochanter. At the same time the diminution of the fourth trochanter is also accompanied by the development of what I formerly called the processus pectinealis of the Orthopode pelvis (*Földtani Közlöny*, 1899, Budapest), but for which I now adopt the more appropriate name of processus pseudopectinealis. As it is now possible to prove that the development of the processus pseudopectinealis as well as the more complex structure of the teeth are due to *progressive* and not to *retrogressive* evolution, and since it is impossible to suppose that some sort of quite especial *chevauchement de specialisation* is disturbing the *whole* line from *Hypsilophodon* to *Trachodon*, it is equally impossible to sustain the view that the smaller fourth trochanter represents the primary state, and on account of this I think the fourth trochanter in *Hypsilophodon* may be brought forward as one of the principal arguments for sustaining my hypothesis concerning the fourth trochanter.[1]

Conclusion. The following characters in *Hypsilophodon* can be considered as new or definitely settled:—No sclerotic ring. Coronoidal process blunt and low. The dermal predentary certainly edentulous. Præmaxillary with rugosity on the front end. Condylus basi-occipital, and the whole base of the skull very bird-like, reminding us more of some Theropoda than of the true Ornithopodidæ.

[1] Other arguments I intend discussing upon another occasion.

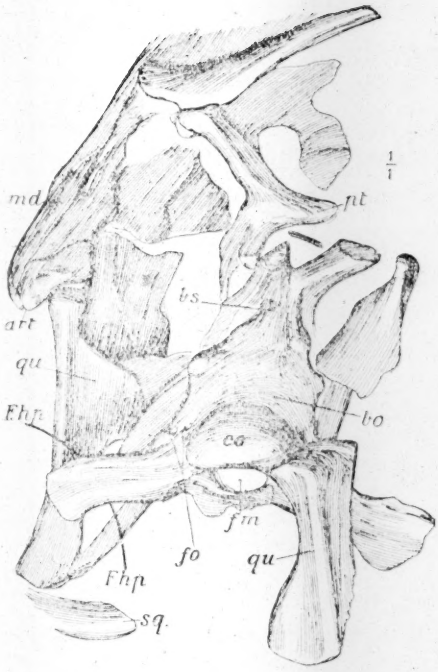


Fig 1

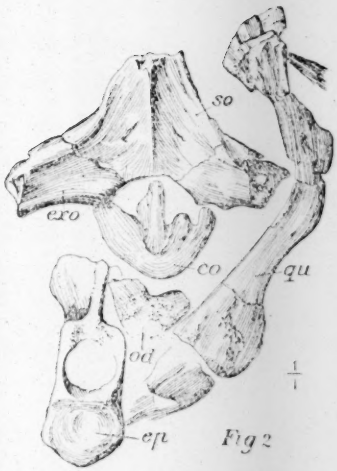


Fig 2

Fig 3.

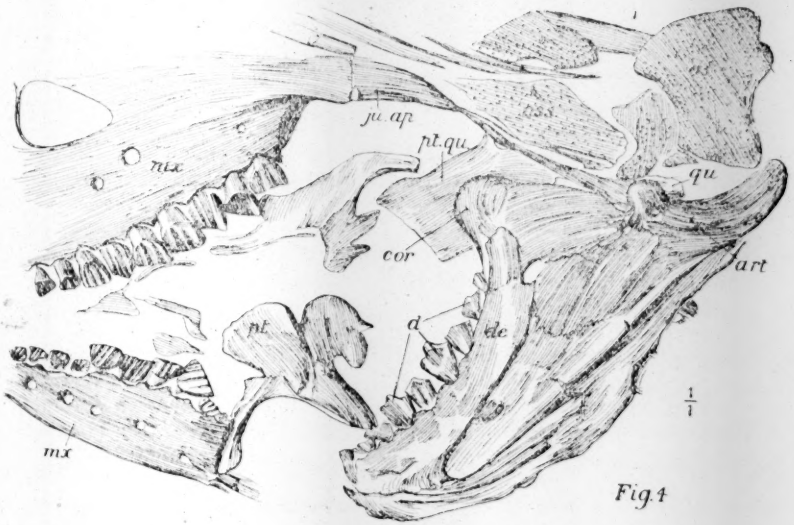


Fig 4

British Dinosaurs : I. *Hypsilophodon.*

Supra-occipital entering largely into the foramen magnum. Processus parotici not raised. Large fossa hypoparotica present. Dermal armour present and well developed. Ossified dorsocaudal tendons run along neurapophysis and chevron bones, and augmenting in number towards the end of the tail.

EXPLANATION OF PAGE-ILLUSTRATION (p. 207).

FIG. 1.—Base of skull of *Hypsilophodon* ($\frac{1}{1}$).
,, 2.—Back of skull of *Hypsilophodon* ($\frac{1}{1}$).
,, 3.—Predentary of *Hypsilophodon* ($\frac{3}{4}$).
,, 4.—Mandible of *Hypsilophodon* ($\frac{1}{1}$).

art.	articulare.	*md.*	mandibulum.
bs.	basi-sphenoid.	*mx.*	maxillare.
co.	condylus.	*od.*	processus odontoideus.
cor.	coronoideum.	*oss.*	dermal ossifications.
d.	dentes.	*pd.*	predentary.
de.	dentale.	*p.p.*	processus paroticus.
ep.	axis (epistropheus).	*pt.*	pterygoid.
exo.	exoccipitale.	*pt.qu.*	processus pterygoideus quadrate.
f.hp.	fossa hypoparotica.	*qu.*	quadratum.
f.m.	foramen magnum.	*so.*	supra-occipitale.
fo.	foramina of cranial nerves.	*sq.*	squamosum.
ju.ap.	jugal apophysis of maxillary.	*sy.*	symphysis mandibuli.

III.—On a Lepidodendroid Stem from the Coal-measures.

By Bernard Smith, B.A., Sidney Sussex College, Cambridge.

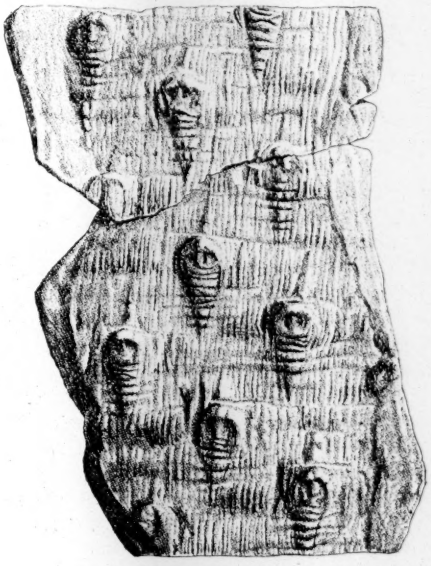
AMONG the numerous Lepidodendroid remains in the Geological Department of the British Museum (Nat. Hist.), there is one which presents several characters of unusual interest. It is a cast, obtained from the Middle Coal-measures of South Staffordshire, near Dudley, and belongs to the Johnson Collection.[1]

A portion of the specimen is figured on p. 209. It will be noticed that the mammillated leaf-cushions are distant from one another, and are separated by broad bands of striated bark. This is an unusual feature in the case of British Lepidodendra. The preservation is fairly good, except in the details of the leaf-scar. In the specimen thirteen leaf-cushions are represented, forming portions of five spiral series. The cushions are rhomboidal in outline, and at first sight do not appear to be very sharply marked off from the bark. On closer inspection, however, they are seen to be moderately well defined, although the lateral angles are flattened and obscured by the encroachment of the bark. They measure from 1·8 to 2 cm. in length, and from ·6 to ·7 cm. at their greatest width. The upper and lower extremities lie in one plane, which is the median plane of the cushion, and are inclined neither to the right nor to the left (cf. *Lepidodendron serpentigerum*). The cushions stand out in high relief, and depart somewhat from the form of a low truncated pyramid so commonly seen amongst Lepidodendra. However, this is in no wise remarkable, for examples of Lepidodendra having raised cushions

[1] Registered number V. 1233.

are not rare, in cases where the stems have to some extent escaped crushing. In profile each one may be compared with a wall-bracket, in which the shelf is represented by the knob-like projection situated above the leaf-scar. The upper and lower divisions of the field are ornamented by a central keel.

The leaf-scar is placed, not at the apex of the cushion, as in many species of Lepidodendra, but in a subordinate position, below the apex. The details of the scar are somewhat indistinct. The upper extremity appears to be slightly notched, the lateral angles are obscure owing to the above-mentioned overlap of the bark, and the base is truncated. A print, presumably the leaf-trace scar, can be distinguished, but the preservation is not sufficiently good to enable one to recognise the parichnos. On that portion of the field lying below the leaf-scar a few transverse wrinkles occur. They are usually somewhat oblique, tending to coalesce, and might, as in the case of *Lepidodendron Wortheni*, be regarded as a specific character. In addition there are a number of other folds, clearly seen in the figure, which run right across the cushion and are continued in the bark on either side. These are almost certainly due to shrinkage, and are not the result of natural growth.



Lepidodendron sp., from the Middle Coal-measures near Dudley. Nat. size.

The most interesting feature presented by this cast is the fact that the leaf-cushions are widely separated. Each cushion is placed at a distance of 1·6 to 1·7 cm. from its neighbour in the same spiral, and 2·3 cm. from its nearest neighbour in the spiral above or below. These measurements are taken from centre to centre of the leaf-scars.

The leaf-cushions are thus entirely separate from one another. Two examples of *Lepidodendron serpentigerum*,[1] König, derived from Newcastle and now preserved in the British Museum, have been found to measure 1·1 cm. and 1·6 cm. respectively from scar to scar; but the cushions occupy a much greater relative proportion of the external surface of the stem than they do in the present case, whilst they are connected with one another by tail-like prolongations running from the lower extremity of the leaf-cushion above to the upper extremity of that beneath. It appears that it is not uncommon in some species of Lepidodendra to find the cushions separated by a certain amount of bark, as in the instance above cited, where the two occupy almost equal areas. But it certainly is unusual that such a relatively large proportion of the whole area of the stem or branch—roughly three-fourths of it—should consist of bark. To quote Mr. Kidston[2]: "The leaf-cushions are arranged in steep spirals and are contiguous, as in *Lepidodendron ophiurus*, Brongt., or more or less distant, as in *Lepidodendron rimosum*, Sternb., or *Lepidodendron serpentigerum*, König, where the cushions end in tail-like prolongations, by which the various members of the same spiral series are connected to each other. In some species, however, the leaf-scars are contiguous or more or less distant, according to the growth or age of the individual. This is seen in *Lepidodendron aculeatum*, Sternb. In some species, as in *Lepidodendron serpentigerum*, König, the leaf-cushions are always distant, so far as at present known, and the interfoliar space is ornamented with fine irregular wavy lines, and a somewhat similar form of ornamentation of the bark appears to be a constant character in all species where the leaf-cushions are distant."

The bark is wrinkled longitudinally, the fine corrugations anastomosing at small angles. The striæ do not sweep round the cushions, as in *L. serpentigerum*, *L. veltheimianum*, *L. corrugatum*, and some other species; but terminate sharply against them. At the widest part of the cushion they sweep over its angles, maintaining, however, their longitudinal direction. We might compare these striæ with those of *L. distans*,[3] Lesqr., which also end abruptly at the cushions, but do not encroach upon them.

The general appearance, the shape of the specimen, and the fact that it has, in all probability, not been considerably crushed, all seem to favour the idea that it is a part of an old branch or stem. Moreover, in some Lepidodendra we find that as the stem advances towards maturity, the leaf-cushions often tend to become more elongated, especially in cases where the cushions of the young branches are as broad, or broader than long. For example, those of *L. dichotomum*, Zeiller, are shorter than broad; those of *L. obovatum*, Sternb., as long as broad. So we might argue that the length of

[1] Registered number 38,089.

[2] Kidston, "Carboniferous Lycopods and Sphenophylls": Trans. Nat. Hist. Soc. Glasgow, N.S., vol. vi, p. 46 (1899–1900), 1901.

[3] Regarded as identical with *L. serpentigerum*, Kön., by Kidston: Cat. Palæoz. Plants Brit. Mus., p. 157, 1886.

the cushions in the specimen described here is indicative of advanced age, though this evidence, being merely negative, is not of any great value. Although there is no means of ascertaining, in the absence of other specimens, whether this species had approximating or contiguous leaf-cushions at a younger stage in its development, the fact still remains that the relative distances between the leaf-cushions, as compared with those of other Lepidodendra, even in advanced age, is more or less exceptional. In this respect no British species with which I am acquainted approximates to it. *Lepidodendron serpentigerum*, König, and *L. distans*, Lesqr., offer the closest resemblances; but in view of the indifferent preservation of the leaf-scar, I consider that it would be unwise to attempt either to classify it with any existing British species or to give it a specific name of its own.

My thanks are due to Miss Woodward for the figure with which this article is illustrated, and to Mr. Newell Arber, both for introducing the specimen to my notice and for the interest that he has taken in this work.

IV.—On a Collection of Trilobites from the Upper Cambrian of Shantung, North China.

By Henry Woodward, LL.D., F.R.S., F.G.S.

THROUGH the kindness of my friend Mr. E. T. Newton, F.R.S., of the Geological Survey Museum, Jermyn Street, I was placed, in October, 1902, in correspondence with the Rev. Samuel Couling, M.A., of the English Baptist Mission, Ching-chou-fu, Kiao-chow, North China, who obligingly transmitted to me several fossils which he had obtained from "West Shantung, and south of Tsing-tshou-fu, 36° 40′ N. lat. and 118° 40′ E. long." He referred me to Richthofen's Atlas, on which the hills where the fossils had been obtained are marked "Mittel und Ober Sinisch"—between Cambrian and Silurian in age.

The collection, which was added to by Mr. Couling a year later, contains several portions of Trilobites and a slab entirely covered with detached Trilobitic remains, reminding one of similar beautiful slabs (frequently to be seen in museums) from the Wenlock shale of the Wren's Nest, Dudley, England. In addition to the Trilobites, there were several Cephalopods and photographs of others, from the same province. Some of these straight-shelled Nautiloids, collected by Mr. Couling, have already been figured and described in this Magazine by Mr. G. C. Crick in November, 1903,[1] and a further paper has been promised by the same author. An account of the Trilobites would have followed some time since (indeed, figures had been already prepared), but having learnt that a similar collection from Shantung had already been sent to Berlin, and published by Herr H. Monke (Berlin), in 1903, I delayed doing so until I was in possession of a copy of that paper, of which I here subjoin an abstract.

[1] See Geol. Mag., Dec. IV, Vol. X (1903), pp. 481–485, Pl. XXII, etc.

To this I propose presently to add a note on the Trilobites and upon some additional specimens collected by the Rev. S. Couling, and to give a photographic reproduction of a part of the slab sent to me by him. All the specimens (including the slab) have, by his desire, been presented to the Geological Department of the British Museum (Natural History), Cromwell Road, S.W.

The following is an abstract of Herr H. Monke's paper, entitled:—"Contributions to the Geology of Shantung.—I. Upper Cambrian Trilobites from Yen-tsy-yai." [1]

The 'Sinische Formationsreihe' (Sinic formation), as it is called by Von Richthofen,[2] is a series of strata of from 4000–7000 metres in thickness, composed of conglomerates, sandstones, clay-slates, and limestones, which in Northern China covers the steeply inclined folds of the Archæan formation, and which in turn is covered almost conformably by the Carboniferous formation. The lowest members of this series consist of conglomerates and coarse sandstones, the products of disintegration by the sea, transgressing from S.E. to N.W. These are succeeded in ascending order by an alternating succession of siliceous limestones with arenaceous or argillaceous strata, and finally by pure limestones, partly of a peculiar, globulitic form. Accordingly, we may distinguish between a Lower Sinic arenaceous, a Middle Sinic arenaceo-calcareous, and an Upper Sinic calcareous division. Von Richthofen regards this series of strata as belonging on the whole to the Cambrian, but he is of opinion that "the formation in China extends much lower down and therefore embraces a much longer period, whilst upwards it may extend into the Lower Silurian without any appreciable break." [3]

[p. 104] This view rests on the results at which Dames and Kayser [4] had arrived from the study of numerous Trilobites and some Brachiopoda collected by Von Richthofen in the Upper Sinic Limestones near Sai-ma-ki, Ta-ling, and Wu-lo-pu, in Liautung.[5] According to Dames, who worked out the Trilobites, the fauna of Sai-ma-ki consists chiefly of two species of the genus *Conocephalus*, whereas the genera *Anomocare* (3 species), *Liostracus* (1 sp.), and *Agnostus* (1 sp.) occur only quite isolated. Near Ta-ling the limestones, which here are partly globulitic, contain, with the exception of *Agnostus*, the same genera (4 *Conocephalus*, 2 *Anomocare*, 2 *Liostracus*), the species being, however, different, with the exception of *Conocephalus frequens*,[6] which is the most common of all in both localities. Dames therefore considers the two faunas as essentially

[1] Extracted from the Jahrbuch d. kön. Preuss. Geolog. Landesanstalt und Bergakademie for the year 1902, vol. xxiii, fasc. 1, pp. 103–151, Tafel iii–ix (Berlin, 1903).

[2] "China," vol. ii (1882). See especially pp. 73, 79, 107, 223, 316.

[3] Op. cit., p. 108.

[4] "China," vol. iv (1883).

[5] These three localities are situated near the Corean frontier: Ta-ling about 51 kilometres north of Sai-ma-ki, and Wu-lo-pu about 62 kilom. north-west of Sai-ma-ki, or 28 kilom. west of Ta-ling.

[6] The assumption on p. 17 (op. cit.) that *Anomocare planum* occurs likewise near Sai-ma-ki is, according to pp. 28 and 30, apparently a mistake.

contemporaneous and nearly corresponding to the horizon of the Scandinavian Andrarum Limestone, and to the lowest division of the Potsdam Sandstone in America.

The fauna of Wu-lo-pu, on the other hand, is characterized by the new genus *Dorypyge*, in addition to which there are only found the genera *Liostracus* (1 sp.) and *Anomocare* (1 sp.); no other species, however, is in common with the before-mentioned faunas.[1] With the genus *Dorypyge* Dames associates *Dicellocephalus gothicus* and *D. quadriceps*, from the 'Quebec group' of Utah, and concludes therefrom that the strata of Wu-lo-pu are of Lower Silurian age.

At a later date Gottsche[2] found Sinic strata, extending over 25 kilom., in Corea, near the frontier towards Liautung; above [p. 105] massive siliceous sandstones there follow fossiliferous marly slates and bituminous limestones, underlying massive and in part globulitic limestones, devoid of fossils. According to preliminary information, the fauna consists chiefly of Trilobites of the genera *Agnostus*, *Dorypyge*, ? *Remopleurides*, *Conocephalus*, *Crepicephalus*, and *Anomocare*; two species (*Dorypyge Richthofeni* and *Anomocare planum*) occur also in the fauna of the Wu-lo-pu, and one (*Anomocare majus*) in that of Sai-ma-ki. Accordingly, Gottsche places the marly slates and bituminous limestones upon the same horizon as the Andrarum Limestone, whilst he regards the globulitic limestones, devoid of fossils, as probably of Lower Silurian age; he therefore arrives at almost the opposite conclusion to Dames, who unites the *Dorypyge* strata of Wu-lo-pu with the Lower Silurian, and the globulitic limestones of Ta-ling, as well as the strata of Sai-ma-ki, with the Andrarum Limestone.

Walcott,[3] who places *Dicellocephalus gothicus* and *D. quadriceps* in the genus *Olenoides* (Middle Cambrian), and considers *Dorypyge* to be synonymous with *Olenoides*, regards the whole of the 'fauna of Liautung' as Middle Cambrian, and views the Sinic strata as a development of the Cambrian, entirely corresponding to that of his 'Rocky Mountain province' of Western America. This view is shared on the whole by Trech[4]; he, however, retains *Dorypyge* as distinct from the Lower and Middle Cambrian genus *Olenoides*, though admitting their near relationship; he also quite correctly separates the various faunas of Liautung. The *Dorypyge* strata of Wu-lo-pu are held to be older than the Middle Cambrian limestones of Sai-ma-ki and Ta-ling. Walcott,[5] having in the meantime made known a true *Dorypyge* from the Lower Cambrian of America, Trech points out that the *Dorypyge* strata of Wu-lo-pu may be even of Lower

[1] *Dorypyge Richthofeni* is given on p. 27 as occurring also at Ta-ling; this in opposition to the remarks contained on p. 31; however, on some specimens in the collection of the 'Museum für Naturkunde,' this locality has been altered by Dames himself into 'Wu-lo-pu.'

[2] "Geologische Skizze von Korea": Sitz.-Ber. d. Ak. d. Wiss. z. Berlin, Jg. 1886, p. 857.

[3] Correlation papers, Cambrian: Bull. U.S. Geol. Surv., No. 81, 1891, p. 377.

[4] Leth. geogn., vol. ii, pt. 1, 1897, p. 58.

[5] 10th Ann. Rep. U.S. Geol. Surv., p. 644.

Cambrian age. Matthew,[1] however, maintains the Middle Cambrian [p. 106] age of the Chinese *Dorypyge*, but regards this genus in a larger sense, viz., as including in part *Olenoides*. In accordance with this view *Dorypyge* would make its appearance in the Lower Cambrian, attain its acme in the Middle, and extend also into the Upper Cambrian.

Recently Bergeron[2] has described a sandstone and a limestone slab from China, which exhibit remains of a quite peculiar new fauna. The sandstone slab comes from the mountains north of Toung-yen-Fou, from a nearly vertically elevated complex of strata, with horizontally deposited Sinic sandstones overlying them; the slab contained only a few remains of a new genus of Trilobites, *Arthricocephalus*. Bergeron does not pronounce on the geological age of the stratum; but from the stratigraphical relations and from the diagrammatic sketch of *Arthricocephalus* (op. cit., p. 515, text-fig. 9), a Lower Cambrian or even a pre-Cambrian age may be assumed.

The limestone slab, which had been bought from a dealer in curiosities in Peking, and was said to come from the mountains to the north of that city, is, according to the photographic illustration (op. cit., pl. xiii), completely covered with remains of Trilobites, referred by Bergeron to the genera *Agnostus* (Regii group), ? *Calymmene*, *Olenoides*, ? *Dicellocephalus*, and to the new genus *Drepanura*. From what will be said further on, the correct determination of the *Agnostus* and *Olenoides* may be doubted; it is precisely from these forms that Bergeron concludes the Peking slab to be of Middle Cambrian. Concerning the strata of Liautung, Bergeron is of opinion that they cannot be with certainty referred to the Middle Cambrian; in his opinion neither is *Dorypyge* (generically different from *Olenoides*), nor are *Conocephalus*, *Anomocare*, and *Liostracus* characteristic of this horizon. Moreover, in his view, the *Agnostus* (from Sai-ma-ki) is a member of the 'Longifrontes,' which is supposed to have been "trouvé à un niveau inférieur à celui des *Dorypyge*" (from Wu-lo-pu), is suggestive of the Upper Cambrian, where this group is said to reach the maximum of its development.

[p. 107] Considering these divergent views on the age of the Sinic strata, as well as the imperfect knowledge of their faunas, we are under great obligation to Herr Bergmeister F. Koerfer for having collected, amongst others, numerous slabs from the Upper Sinic Limestones with well-preserved fossils. The collections were handed over to the Royal Prussian Geological Survey and 'Bergakademie,' by whom Herr H. Monke states he has been entrusted with the examination of the fossils. One particularly well-preserved slab (reproduced on pl. ix) had been presented to Baron v. Richthofen; this, he says, has also been kindly entrusted to him. The Sinic fossils come from two separate localities,

[1] Studies on Cambrian Faunas: Trans. R. Soc. Canada, ser. II, vol. iii (1897), p. 186; and vol. v (1899), pp. 56, 62.

[2] "Etude de quelques Trilobites de Chine": Bull. Soc. géol. France, sér. III, t. 27 (1899), p. 499.

Wang-tschuang and Yen-tsy-yai, in the province of Shantung, from strata which petrographically and faunistically are totally different. Nothing is known about the particulars of the deposits, Yen-tsy-yai not having been visited by Herr Koerfer, nor, indeed, by any European[1]; the indication of the locality rests solely on the information of the Chinese, from whom the slabs were purchased. In his report[2] Herr Koerfer makes the following remark on this point: "The Palæozoic strata begin in Shantung with an alternation of siliceous limestones, reddish clay-slates, and red or yellow sandstones. On this complex of strata, called Middle Sinic by Von Richthofen, follows the Upper Sinic formation, which is composed almost exclusively of massive beds of limestone, and [p. 108] contains numerous fossils of the primordial fauna. Two deposits deserve special mention. The one is situated near the village Wang-tschuang (between Möng-yin-hsien and Ichui-hsien), where limestone beds densely filled with Trilobites are to be found at about 200 metres above the limit of the Middle Sinic formation of the Valleys. The fossils correspond completely with those collected at Liautung by Von Richthofen.[3] The second deposit is situated one day's journey to the north-west of Wang-tschuang, near the village Yen-tsy-yai, whence beautiful slabs with Trilobites (styled 'petrified swallows'[4] by the Chinese) are put into commerce. These are more recent Trilobites than those of Wang-tschuang, and probably Upper Silurian[3] in age."

Finally, the Shantung Bergbau Gesellschaft at Berlin presented to the Museum of the Geological Survey and Bergakademie two limestone slabs exactly corresponding with those from Yen-tsy-yai, and derived, according to Herr Bergassessor Krause, from the mountainous district N.N.E. of Möng-yin-hsien, which agrees with the information reported above. Unfortunately (owing to an assault made upon him by the Chinese), Herr Krause had to leave behind the majority of his geological collections.

Herr H. Monke then proceeds to describe the Trilobite-bearing limestones and shales of the Yen-tsy-yai; and he states that there will be given in a later paper descriptions of the Brachiopoda of Yen-tsy-yai and of the fauna of Wang-tschuang, together with the general results.

[1] After the termination of the present memoir I have received the information that Herr Bergassessor Axt has been commissioned by the Schantung Bergbau Gesellschaft at Berlin to survey the neighbourhood of Yen-tsy-yai. The results of his investigations will be reported on a future occasion.

[2] "Geologische Skizze der Provinz Schantung unter Benutzung der Karte von F. v. Richthofen," Berlin, 1891. Printed in the Imperial Typography; 4 pp. and a map. (Short preliminary notice in Zeitschr. d. Deutsch. geol. Ges., vol. liii, 1900, Verh., p. 109.)

[3] This is not correct.

[4] *Drepanura Premesnili*, Bergeron, and *D. Ketteleri*, H. Monke.

(*To be continued.*)

V.—The Occurrence of Glacial Clay on the Cotteswold Plateau.

By C. Callaway, D.Sc., F.G.S.

MR. L. RICHARDSON, F.G.S., having informed me that he had seen gravels at a high level on the road leading from Stow-on-the-Wold to Burford, I visited the locality, accompanied by Mr. J. W. Gray, F.G.S. About $3\frac{1}{8}$ miles north of Burford, at the corner of the turning to Tangley, we came upon a deposit of clay with northern erratics in a quarry of oolite. As the position of such a formation was unexpected, and might be important, it seems desirable to record the discovery.

The Locality.—The deposit lies on the Cotteswold plateau, near its eastern margin, about midway between Cheltenham and Oxford, and about the same distance (18 miles) south-by-east of Meon Hill, the most northerly spur of the Cotteswolds. The elevation is approximately 650 feet above O.D., and 350 feet above the river Evenlode, which lies $2\frac{1}{2}$ miles to the east. The section is on a spur of Oolite about 6 miles long, projecting from the mass of Tainton and Shipton Downs, to the north-north-west, and then curving round to the north-west, rising towards its northerly termination to over 800 feet in Wyck Beacon. From the quarry the ground slopes rather sharply in both directions, to the Evenlode on the east, to a tributary of the Windrush on the west; so that the clay lies on the very apex of a pent-house ridge.

The Clay.—The rock for which the quarry is worked is Great Oolite. It has been excavated along a north and south line parallel with the road for perhaps 50 yards, exposing a vertical section whose maximum height is about 10 feet. The strata dip gently in a westerly direction. The rock is much fissured, the fissures being very irregular, so that at some points they broaden out at the top into wide pockets, while in others they are little more than open joints. Some of the narrow ones go down to the foot of the cliff. All the fissures are packed tight with clay. It has found its way not only down to the lower end of vertical fissures two inches wide, but even horizontally into clefts of less than half of that width.

The clay is stiff and hard. It is of two kinds, grey-blue and brown, the former more compact and finer-grained than the other. They are irregularly intermixed, without the faintest indication of bedding or lamination. The difference of colour is original, and not the result of chemical change subsequent to the intrusion of the clay. This is seen in bulk-analysis and microscopic examination.

The blue clay, triturated with water in a test-tube repeatedly, and allowed to settle, appears to the naked eye an almost pure clay of extremely fine texture. It gives no effervescence with acid. Examined with a one-inch objective, the bulk of the material is still seen to be very minute, but is mixed with a small proportion of larger particles of two kinds, (1) brown sand and (2) very small granules and microliths of clear minerals, some of which have a high refractive index.

The brown clay, treated in the same way, presents very marked differences. More than one-half of it is a quartzose sand of angular and subangular grains stained with a reddish-brown colour, the remainder being a pale-red clay with a small proportion of minute clear minerals.

The Erratics.—These are of all sizes up to 3 inch diameter. The following are the chief varieties :—

(1) Quartz, very much rolled.
(2) Quartzite, (*a*) white and (*b*) grey, well rolled.
(3) Chert, (*a*) white, (*b*) grey, with impressions of small encrinite stems, and (*c*) banded black and white ; not so well rolled as the quartz and quartzite ; some specimens subangular.
(4) Coarse quartzose grits, grey and reddish (? Millstone-grit) ; well rounded.
(5) Flints, (*a*) brown with white crust, (*b*) white (? weathered) ; rounded and subangular ; 1 to 2 inches diameter.
(6) Brown ironstone (? Lias Marlstone), small, subangular.
(7) Grey oolite, subangular fragments and numerous spherical grains.
(8) Reddish-brown iron-shot oolite ; locality not identified, though a specimen was submitted to several experts.

Derivation of the Materials. — The origin of the clays is not determined with certainty. The blue variety suggests the Lower Lias, while the red sandy clay may have been derived from Keuper Marls and Sandstone.

The pebbles of quartz and quartzite have almost certainly come from Triassic conglomerates north of the Cotteswold area. The cherts and grits are presumably Carboniferous, and may have travelled from Derbyshire. For the flints a north-easterly origin is probable. The ironstone and oolites, with perhaps the blue clay, are the only materials that appear to be of local derivation.

Some light is thrown upon the derivation of the erratics by a study of the deposits which occupy the Evenlode valley and the northerly extension of its axis along the valley of the Stour, which drains into the system of the Warwickshire Avon. Commencing at the southern point, we observe exposures of sand and clay at Milton-under-Wychwood, a mile and a half east of our Tangley section, about 250 feet lower than the section, 100 feet above the Evenlode at Shipton, and 400 feet above O.D. The highest deposit is near the road at Upper Milton. It consists of sands, brown and grey interbedded, excavated to a depth of 10 feet, and overlain by from 1 to 3 feet of brown clay containing quartz pebbles and small angular flints. There is a similar clay in a field to the east at a little lower level. It is 3 to 4 feet thick, and is traversed by a rough vertical jointing. Shaken up in water, it is seen to resemble the brown clay of the Tangley section. About 100 yards distant is a section of clay, with quartzite pebbles, overlying a gravel of small angular pieces of oolite, underlain by red sand. It will be noticed that the uppermost layer in these three sections is a brown sandy clay, not dissimilar to the brown clay of the ridge above.

Passing northwards up the valley, we come to Kingham, 4 miles north of Shipton. Here is exposed a good section of oolite-gravel, with interbedded seams of oolite-sand. The fragments are water-worn. Scattered through the mass are some well-rounded pebbles of quartz, quartzite, and quartzose grit, with some bits of ironstone. Towards the top of the section a few of the quartzite pebbles have their longer axes vertical. Two miles further up the valley, east of Adlestrop station, there are arenaceous gravels, containing many flints, some of them of large size. Near Evenlode, $1\frac{3}{4}$ miles due north, is the boulder of Millstone-grit indicated on the Geological Survey Map. Its dimensions are 20 by 14 by 14 inches. It is well rounded.

The well-known gravels of Moreton-in-the-Marsh are $2\frac{1}{2}$ miles further to the north-west. They lie near the water-parting of the Evenlode and the Stour, at an elevation of about 425 feet above O.D. The sandy matrix contains numerous large and small unworn flints and well-rounded quartzite pebbles, with an inconspicuous proportion of igneous and other rocks. Many of the flints and pebbles lie with their longer axes vertical. The valley to the north of Moreton is thickly strewn with similar materials. I also observed boulders of Carboniferous Limestone, grey felsite or hornstone, and other erratics. W. C. Lucy[1] describes the gravels of this district, and he notes the occurrence of other foreign derivatives, including white chalk and red chalk. I have shown some of the latter to Mr. W. Whitaker, and he admits the accuracy of the identification.

The origin of the Moreton gravels has been discussed.[2] Mr. S. S. Buckman leans to the opinion that they were deposited by a river, when the surface features of the country were widely different. The abundance of flints, with a less proportion of white and red chalk, would seem to point to a derivation from Lincolnshire or Yorkshire, but it is difficult to conceive of a downward flow from that direction to the Cotteswold Hills in later Tertiary times. This hypothesis appears also to be inconsistent with the enormous abundance of large unworn flints north of Moreton as compared with their scarcity south of that point. Mr. T. Mellard Reade is disposed to attribute the formation of the Moreton gravels to floating ice in the Glacial Epoch. Some form of the ice-theory is, I think, necessary to explain the facts. Ice in the Midland area moving southwards might well be arrested by the projecting mass of the North Cotteswolds, and morainic matter would accumulate at the opening of the Moreton gorge.

The Tangley section also appears to me inexplicable except as the product of ice-action. It lies on the summit of the ridge, and the materials could not have been river-borne in Glacial or post-Glacial times. The clay is quite unlike an ordinary sediment: not only is lamination absent, but the two kinds of clay are intermixed in the most irregular manner without being blended with each other. They are both traversed by numerous slickensides, some of which

[1] Proc. Cotteswold Nat. Field Club, vol. v, pp. 71–142.
[2] Ibid., vol. xiv, pp. 111–118.

are marked with parallel striations and grooves, as if portions of clay had moved over each other. It is difficult to resist the conclusion that the clay has not been deposited in the fissures by water, but has been introduced by pressure when in a partially consolidated condition. An ice-sheet pushing forward clayey morainic material might have conceivably produced the effect, but I hesitate to pronounce a definite opinion on such a limited section.

W. C. Lucy remarks[1] that clay containing quartz pebbles is scattered "nearly all over the Cotteswold range," sometimes up to a thickness of 3 feet, and often filling pockets in the oolite.

The boulders and some of the gravels and clays found in the Evenlode valley between Shipton and Moreton tend to confirm the evidence of the Tangley section by suggesting the agency of ice, at least as far south as Tangley, at lower levels.

Since writing the above, I have referred to Mr. David's paper[2] "On the Evidence of Glacial Action in South Brecknockshire and East Glamorganshire." He describes the shattering of rocks by ice-action, and states that "boulder-clay has been forced into the shattered strata to a depth of 12 feet at least."

I trust that these notes will attract to the district the attention of those who have made a special study of glacial phenomena.

VI.—On Earth-Shakes in Mining Districts.

By Charles Davison, Sc.D., F.G.S.

THE term 'earth-shake' has been applied to local disturbances of the earth which owe their origin, either in part or wholly, to artificial causes. Typical examples of earth-shakes are those which are occasionally felt at Sunderland and other places on the magnesian limestone of the Durham coast, and which have been attributed by Prof. Lebour to rock-falls in underground channels, enlarged no doubt by pumping in connection with the local water-supply.[3] Other examples are the shocks frequently felt in mining districts, and either caused or precipitated by mining operations. Earth-shakes of this class have occurred in the Rhondda Valley in Glamorganshire on June 22, 1889, April 11 and May 2, 1894, and October 16, 1896; in the neighbourhood of Camborne on June 4 and 10, 1902; at Pendleton, near Manchester, on February 27, 1899, and April 7, 1900; at Kilsyth in Stirlingshire on February 16, 1898, and in various other districts.

The last group of earth-shakes are found to possess certain features in common:—

(1) The disturbed area is small, from one to five miles in diameter; and, as a rule, the boundary is approximately circular in form.

[1] Ibid., vol. vii, pp. 50–61.

[2] Quart. Journ. Geol. Soc., 1883, p. 39.

[3] "On the Breccia-gashes of the Durham Coast and some Recent Earth-shakes at Sunderland," North of England Inst. of Min. Eng. Trans., vol. xxxiii, 1884, pp. 165–174; "On some Recent Earthquakes on the Durham Coast and their probable Cause," Geol. Mag., Vol. II, 1885, pp. 513–515.

(2) The intensity of the shock is great near the centre of the area, and dies away rapidly towards the boundary.

(3) The shock and sound are of short duration, the sound in four out of every five records being compared either to the fall of a heavy body or to an explosion.

We may infer, from these facts, that the centre of disturbance is situated at a very slight depth below the surface, and also that it is, as a rule, of small dimensions. Falls of rock in pit-workings would satisfy these conditions and would produce shocks very similar to those observed, but none was found on any of the above occasions. Many rock-falls are caused or accompanied by disturbances known in the Staffordshire Colliery districts as 'bumps' or 'goths.' They are probably due to "the sudden release by fracture of a state of tension in the strata either pre-existent or brought about by the mine-workings."[1]

Another probable cause of earth-shakes in mining districts is that suggested in a recent paper in this Magazine.[2] It is noticeable that, in all the above cases, the centres of the disturbed areas lay close to faults; and those of the Pendleton earth-shakes were on the downthrow side of the Irwell Valley fault, the coal having been worked away right up to the fault. By the withdrawal of the coal, the rock above is deprived of most of its support, and tends to sink down and close up the worked-out seam. Especially would this be the case in the neighbourhood of a fault, where a series of small fault-slips would take place, each giving rise to a shock, violent in the district immediately above it but rapidly fading away in strength, and as a rule of brief duration and disturbing a nearly circular area.

Direct proof of the occurrence of such semi-artificial fault-slips could no doubt be afforded only by careful and prolonged observation and experiment; but indirect evidence supporting the above explanation is furnished by three recent earth-shakes, those of Blisland (Cornwall) on August 25, 1895, of Camborne on June 4, 1902, and of Barnsley on October 25, 1903.

Blisland Earth-Shake: August 25, 1895.

Time of occurrence, about 12.30 p.m.; intensity, 4; epicentre, in lat. 50° 31·9′ N., long. 4° 40·9′ W.; number of records, 20, from 19 places, and negative records from 2 places.

The Blisland earth-shake has already been described in this

[1] W. N. Atkinson, Report of H.M. Inspector of Mines for the Stafford District for the year 1903, p. 15. Mr. Atkinson remarks that the terms 'bump,' 'goth,' etc., refer to "a sort of explosion or eructation in the strata which in some cases is so severe as to be comparable to local earthquakes. They occur chiefly in thick and deep seams, and vary greatly in intensity both as to sound and effect on the strata. The sound is often compared to that of a shot, and appears to occur sometimes in the coal itself and sometimes in the strata overhead; in heavy bumps the sound is more like thunder. The effect of the bumps on the strata varies greatly; in slight cases there is no observable effect except the sound; when more severe there is vibration, and falls of roof may take place, or coal be burst off the face; in severe cases timber is broken or reeled out, and the mine appears to be about to collapse. In some cases the floor bursts up instead of the roof falling."

[2] Geol. Mag., Vol. VII, 1900, pp. 174–177; Vol. VIII, 1901, p. 361.

Magazine.[1] It disturbed a small, but elongated area, 6 miles long, nearly 2 miles wide, and containing 9 square miles. Its centre is half a mile north of Blisland, and the direction of its longer axis E. 5° N. and W. 5° S. The shock was merely a slight tremor, of intensity 4. The sound was heard by all the observers, and was compared to passing trains, etc., in 33 per cent. of the records, to thunder in 47, and to explosions in 20, per cent. The beginning and end of the sound coincided either quite, or very nearly, with the beginning and end of the shock. No faults are traced on the Geological Survey map in the neighbourhood of the disturbed area; but, close to the centre and southern boundary of the area, are several series of elvan dykes which run almost parallel to the longer axis of the disturbed area.

Camborne Earth-Shake: June 4, 1902.

Time of occurrence, 10.30 p.m.; intensity, 5; epicentre, in lat. 50° 13·4′ N., long. 5° 16·6′ W.; number of records, 22, from 12 places, and 30 negative records from 22 places.

The area affected by this earth-shake is shown in Fig. 1. The boundary, as drawn, is elliptical in form, $4\frac{1}{2}$ miles long, 3 miles wide, and about 10 square miles in area; the centre being about one mile north-east of the centre of Camborne. It is possible,

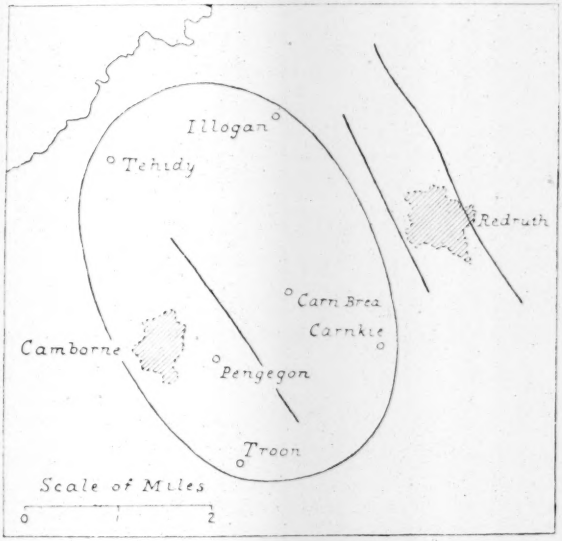


Fig. 1.—Area of the Camborne Earth-shake.

however, that the boundary should extend a short distance, perhaps as much as half a mile, farther to the west, for there are no negative records from the district immediately to the west of Camborne. The direction of the longer axis is N. 24° W. and S. 24° E.

[1] Geol. Mag., Dec. IV, Vol. VII, 1900, pp. 164–166.

The shock consisted of one prominent vibration, like that produced by the fall of a heavy weight, followed by a tremulous motion lasting for one or two seconds. The sound was heard by all the observers. In 15 per cent. of the records it was compared to passing vehicles, etc., in 8 per cent. to thunder, in 31 to loads of stones falling, in 15 to the fall of a heavy body, in 23 to explosions, and in 8 per cent. to miscellaneous sounds; three out of every four comparisons being to types of brief duration. In nearly every case the terminal epochs of the sound coincided with those of the shock.

If the earth-shake were due to fault-slipping, the fault must run from about N. 24° W. to S. 24° E. and pass a short distance, between half a mile and a mile, to the north-east of Camborne. As to the hade of the originating fault there is no evidence furnished by the earth-shake. Of the three faults shown on the map (Fig. 1) the more westerly one closely satisfies the assigned conditions. It is the 'great cross course' of the Dolcoath Mine, and passes through a point about $\frac{3}{4}$ of a mile north-east of Camborne in a direction from N. 33° W. to S. 33° E., heaving the Dolcoath Lode 140 yards to the south. The hade of the fault, as Mr. H. P. Vivian kindly informs me, is practically zero.

Barnsley Earth-Shake: October 25, 1903.

Time of occurrence, 11.5 p.m.; intensity, 7; epicentre, in lat. 53° 31·3′ N., long. 1° 28·2′ W.; number of records, 13, from 9 places, and 12 negative records from 10 places.

As in the two preceding shocks, the disturbed area (Fig. 2) is elliptical in form. It is $5\frac{3}{4}$ miles long, $3\frac{1}{2}$ miles wide, and contains 16 square miles. Its centre is almost coincident with the village of Worsborough, and the direction of its longer axis is N. 38° W. and S. 38° E.

The intensity of the shock was 7 at Worsborough and Hoyland, 6 at Worsborough Bridge and Barnsley, and from these places it died away rapidly towards the boundary. The shock consisted of a single series of vibrations lasting from 3 to 5 seconds. The sound was also of brief duration, being compared either to the fall of a heavy body or to thunder. In the pit at Worsborough it was mistaken for that of an explosion.

As will be seen from the map, there are several faults which are parallel, or nearly so, to the longer axis of the disturbed area. The faults are indicated by broken lines, except one, which is in part continuous. This fault hades to the north-east, its direction in the central portion of the disturbed area is N. 41° W. and S. 41° E., and its course at the surface is on the south-west side of the epicentre. It thus satisfies the observed conditions, and satisfies them more closely than any other fault.

The curved line on the map (Fig. 2) represents the outcrop of the Barnsley Coal-bed within the disturbed area. At the Barrow colliery, which is the nearest to Worsborough, the depth of the bed is about 100 yards. Mr. R. Richardson, the manager of the colliery, kindly informs me that practically the whole of the coal in

this seam has been worked, and that, under the area affected by the earth-shake, it has been exhausted for at least eight or nine years. The Parkgate, Thorncliffe, and Silkstone seams, which are at depths of about 260, 300, and 360 yards respectively, below the Barnsley bed, have also been worked largely.

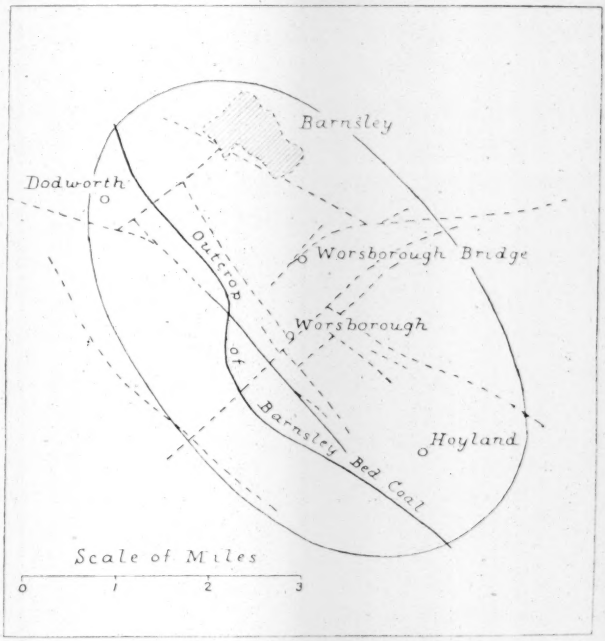


FIG. 2.—Area of the Barnsley Earth-shake.

The areas disturbed by these three earth-shakes are unusually large for this class of disturbance. It would appear, then, that the boundary of the disturbed area is approximately circular in form when the area is small and the shock of slight intensity; but, when the shock is strong and the disturbed area comparatively large, the form of the boundary is distinctly elliptical, and the longer axis of the ellipse is parallel to the neighbouring lines of fault.

The evidence of these shocks thus supports the view that earth-shakes in mining districts are produced by small fault-slips precipitated by the removal of the coal from the immediate neighbourhood of the fault, or partly, perhaps, as Mr. Richardson has suggested to me, by the lowering of the water in that region by pumping in other parts of the mine. In either case—and this is the main point—the earth-shakes would owe their origin to operations of nature, aided very effectively by those of man.

VII.—The Classification of the Phacopidæ.

By F. R. Cowper Reed, M.A., F.G.S., of the Sedgwick Museum, Cambridge.

(*Concluded from p.* 178.)

In North and South America and in South Africa [1] there is a considerable variety of types of the *Dalmanites*-branch in the Devonian period which have in many cases received distinctive subgeneric names; but species retaining the typical characters of the Silurian forms persist at any rate in North America. Many of these Devonian forms show incomplete second lateral furrows on the glabella, these furrows not reaching the axial furrows and causing a partial coalescence of the two middle lateral lobes. This tendency towards the fusion of the first and second lateral lobes of the glabella is a departure from the perfect segmentation found in typical Silurian members of *Dalmanites*, and has caused Clarke [2] to group all such forms together into the subgenus or section *Synphoria*. This type of structure, as Van Ingen [3] has recently shown, is not unknown amongst the Silurian species of *Dalmanites* in America, but it finds its most pronounced development in Devonian time and occurs in the groups *Coronura*, *Corycephalus*, *Odontocephalus*, and *Probolium*, all of which are put by Clarke in the section *Synphoria*. The marginal ornamentation and different processes on the pygidium and head-shield on which these four groups have been founded are scarcely of the same structural importance as the modifications of the glabellar segmentation. As in other families, the spinosity of these forms is the symbol of a last expiring effort before extinction.

Summarising the above facts and deducing therefrom the obvious conclusions, we see that the *Dalmanites*-branch falls into three divisions, which chronologically succeed each other and mark progressive stages of development. Broadly speaking, they may be said to characterise respectively the Ordovician, the Silurian, and the Devonian.

Division I. Primitive and composite forms (e.g., *D. Phillipsi*, Barr., *D. socialis*, Barr., etc.), with pentamerism of head well marked; lobes of glabella distinct; frontal lobe not strongly detached; frontal limb rudimentary or absent; genal angles rounded or shortly pointed; pleuræ of thorax with rounded or pointed ends; pygidium composed of few segments, rarely more than ten, usually of rounded outline. (Subgen. prop. *Dalmanitina*; type, *D. socialis*, Barr.)

Division II. Typical forms (e.g., *D. caudatus*, Brünn., the type of *Dalmanites*, sens. str.), with pentamerism of head well marked; frontal lobe of glabella detached; frontal limb well developed;

[1] Lake: Annals of the South African Museum, vol. iv, pt. 4, No. 9 (1904), pp. 203–213.

[2] Clarke, "Low. Silur. Trilob. Minnesota": Rep. Geol. Nat. Hist. Surv. Minn., vol. iii (1894), p. 732.

[3] Van Ingen: School of Mines Quarterly, Columbia University, vol. xxiii, Nov. 1901, No. 1, p. 67.

genal angles produced into spines; thoracic pleuræ with pointed ends; pygidium strongly mucronate and of many segments, 12–16 in Silurian species, more than 16 in Devonian. Subgenus *Dalmanites*, sens. str. (= *Hausmannia*).

Division III. Highly specialised forms (e.g. *Asteropyge punctata*, (Stein.)), with pentamerism of head sometimes distinct, sometimes more or less lost by fusion of lobes; genal angles generally spined; margin of head frequently furnished with spines or processes; thoracic pleuræ pointed or produced into spines; pygidium of many segments, 16–20 or more, margin usually ornamented with many spines or processes.[1] The most important character in this division, according to Kayser,[2] is the large number of axial rings in the pygidium, which here reaches the maximum in the family. The members of this division include *Asteropyge*, *Coronura*, *Cryphina*, *Corycephalus*, *Odontocephalus*, *Malladaia*, and *Probolium*. The subgeneric independence of these is open to question, and Clarke's name *Synphoria* would include them all.

Branch B.

The second branch of the Phacopidæ, which culminates in *Phacops*, sens. str., branches off from the primitive division of *Dalmanites* as above stated; and an early stage along this line is found in the *Ph. Glockeri* group of Étage E in Bohemia, which is characterised by the general shortening and widening of the cranidium; the partial loss of the pentamerism; the weakening or obliteration of some of the lateral furrows of the glabella (with the frequent splitting or interruption in the course of the anterior one); the rounding of the genal angles; the increased convexity of the thorax; the rounded or obtuse ends of the pleuræ; the comparatively few segments and the rounded non-mucronate outline of the pygidium; and the general absence of spines. In Northern Europe this stage in the development of the true *Phacops* is represented by the Silurian groups named *Acaste* and *Portlockia*,[3] which possess the above characteristics with minor modifications. The third pair of lateral lobes in the glabella is the most persistent and distinct of the lobes, though often tending to become nodular; and in all the features of this stage we see the beginning of modifications leading up to the Devonian type; but we cannot definitely state that they are in the direct line of evolution of the typical *Phacops*; and the significance of their relatively small size is not at present understood. However, the morphological characters of the *Acaste*, *Portlockia*, and *Ph. Glockeri* groups show a transitional condition, and being confined to the Silurian (with

[1] Barrois has recorded from the Silurian of the Pyrenees a species *Dalmanites Gourdoni*, possessing the short pygidium of 10–11 axial rings, like those in Div. II, but with the margin spinose (Ann. Soc. Géol. Nord, x, 1883, p. 151, pl. vi, fig. 1).

[2] Kayser: Zeitschr. deut. Geol. Gesell., Bd. xxxii (1880), p. 19.

[3] *Portlockia* has no phylogenetic or morphological characters of sufficient value to separate it subgenerically from *Acaste*, as Salter recognised years ago.

the possible exception of one or two South American[1] and one South African species which are found in the Devonian[2]), it seems to deserve a distinctive subgeneric name, and that of *Phacopidella* is here suggested; type, *Ph. Glockeri*, Barr.

The final and most highly specialised stage of this branch is found abundantly in the Devonian period in Europe, America, and Asia, but it appears in the higher part of the Silurian in all three continents and also in Australia.[3] It differs only from the previous stage in the greater accentuation of the above-mentioned characters. The glabella tends to become more enlarged, inflated, and transverse; the pentamerism and segmental furrows become very faint or are quite lost; the lateral lobes of the glabella (excepting generally the nodular basal pair) are inseparably fused; the genal angles and extremities of the thoracic pleuræ are invariably rounded; the pygidium is semicircular or transverse, composed of very few segments, and has a simple regular border. There is a complete absence of spinose ornaments. The eyes in typical *Phacops* are large, but they may be reduced in size or absent (*Trimerocephalus*). Gürich's[4] distinction between *Trimerocephalus* and the typical *Phacops* seems quite insufficient and arbitrary.

This final stage may have the old name ***Somatrikelon***[5] revived for it, with *Phacops rana*, Green, as its type.

Branch C.

Lastly, there is the somewhat distinct and disconnected branch of the Phacopidæ of which the earliest types are included in the subgenus *Pterygometopus*.[6] This subgenus appears to be confined to Northern Europe and North America, as Frech has pointed out, and it is characterised by the pentamerous lobation of the head-shield, as we should expect in an early representative of the family, for *Pterygometopus* belongs especially to the lower part of the Ordovician. But there is a constant tendency for the unequal growth of the lateral lobes by the first lobe being developed at the expense of the others; and as the second and third lobes get correspondingly reduced in size by the hypertrophy of the first lobe there is an insensible passage into the condition which marks the subgenus *Chasmops*,[7] in which the second lobe is almost squeezed out or represented by a mere tubercle. The indifferently defined group

[1] Ulrich: Neues Jahrb. f. Miner., Beil. Bd. viii (1893), p. 21 (*Acaste devonica*). Clarke: Archiv. Mus. Nac. Rio de Janeiro, vol. ix (1890), pp. 15–17 (*Ph. brasiliensis*).

[2] Lake: Ann. S. Afr. Mus., vol. iv, pt. 4 (1904), No. 9, p. 205 (*Ph. africanus*).

[3] Etheridge & Mitchell: Proc. Linn. Soc. New South Wales, ser. II, vol. x (1895), p. 486.

[4] Gürich: Verhandl. russ. kais. Miner. Gesell. St. Petersburg, ser. II, Bd. xxxii (1896), pp. 359, 362.

[5] McMurtrie: "Sketches of Louisville and the Fall of the Ohio," p. 74 (Louisville, 1819). The type-species of *Somatrikelon* (*S. megalomaton*, McMurtrie) has been identified with *Phacops rana*, Green (Vogdes, Bibliogr. Palæoz. Crust., Occas. Papers Calif. Acad. Sci., No. 4, 1893, p. 163).

[6] Schmidt: Rev. Ostbalt. Silur. Trilob., Abth. i (1881), p. 62.

[7] McCoy: Ann. Mag. Nat. Hist., ser. II, vol. iv (1849), p. 403.

termed *Homalops*[1] apparently belongs to this stage, and the final result of the extraordinary growth of the first lateral lobes may perhaps be found in *Monorakos*,[2] in which the second and third lateral furrows are only represented by pits. A whole chain of transitional forms showing intermediate conditions between *Pterygometopus* and *Chasmops* can be traced, and there is no hard and fast line between these subgenera. Hall & Clarke[3] diverged widely from the original conception of *Chasmops*, and erroneously interpreted the characters of the type-species by maintaining that the great 'cat's ear' lobes were formed by the coalescence and fusion of the first and second lateral lobes on each side. The definition of the subgenus given by these authors and the species included by them in it cannot therefore be accepted. In all true members of *Chasmops* the second lateral lobes are recognisable and show no coalescence with the first lobes. In the American representatives of *Pterygometopus*, on the other hand, there is, as Clarke[4] has pointed out, a frequent tendency for a coalescence of the first and second lateral lobes, and the culmination of this structural modification seems to be met with in *Monorakos*. For *Pterygometopus* is by no means a homogeneous group, as Schmidt himself has pointed out, and several subdivisions in it may ultimately be recognised, though at present their limits and relations are scarcely well defined.

The connection between *Pterygometopus* and the other branches of the Phacopidæ has not at present been clearly traced, but its relations are undoubtedly wide and varied. Clarke (op. cit.) considers that a Trenton species (*Dalmanites achates*, Billings) is a link between *Dalmanites* and *Pterygometopus*, but his view that lobal coalescence in the glabella is a sign of immature development does not commend itself to me. It may be noted that in many respects, such as the tendency to augment the number of segments in the pygidium and to develop spines on the genal angles, the evolution of the *Dalmanites* and *Pterygometopus* branches has been analogous and parallel. The relations of *Pterygometopus* to *Acaste* (=*Phacopidella*) are also worthy of remark, and Schmidt considers that *Pt. Nieszkowski* forms a passage over to the latter group. The occasional partial loss or reduction of the second lateral furrow of the glabella in *Pterygometopus* (e.g. *Pt. Brongniarti*) is paralleled by certain species of *Acaste* (e.g. *Ph. Downingiæ*).

Proposed Classification.

The results of the above investigation into the relations of the various groups, genera, or subgenera of the Phacopidæ which have been from time to time established show that the following classification may be suggested as based on phylogenetic principles:—

[1] Remelé: Zeitschr. deut. Geol. Gesell., Bd. xxxvi (1884), p. 200.
[2] Schmidt: Bull. Acad. Impér. Sci. St. Pétersbourg, xii, No. 4 (1886), p. 414.
[3] Hall & Clarke: Palæont. New York, vol. vii (1888), p. 63.
[4] Clarke: Lower Silur. Trilob. Minnesota, 1894, p. 732.

I. Subfamily Dalmanitinæ.
1. Genus *Dalmanites*.
Subgenera *Dalmanitina*, nom. prop.
Dalmanites, sens. str. (= *Hausmannia*).
Asteropyge, *Odontocephalus*, *Corycephalus*, *Malladaia*, *Coronura*, *Probolium*, *Cryphina* = *Synphoria*.

II. Subfamily Phacopinæ.
2. Genus *Phacops*.
Subgenera *Phacopidella*, nom. prop.
Phacops, sens. str. (= *Somatrikelon*).
Trimerocephalus.

III. Subfamily Pterygometopinæ.
3. Genus *Pterygometopus*.
Subgenera *Pterygometopus*, sens. str.
Chasmops.
Homalops.
Monorakos.

The earliest and least differentiated members of each genus are comprised in the subgenera *Dalmanitina*, *Phacopidella*, and *Pterygometopus*, sens. str., and being such have many features in common.

Geographical Distribution.

With regard to their geographical distribution, *Dalmanitina* occurs in the northern and southern provinces of Europe in Ordovician times, but *Pterygometopus* only in the northern. *Phacopidella* was spread over both provinces during Silurian times, though with a slightly different type of development.

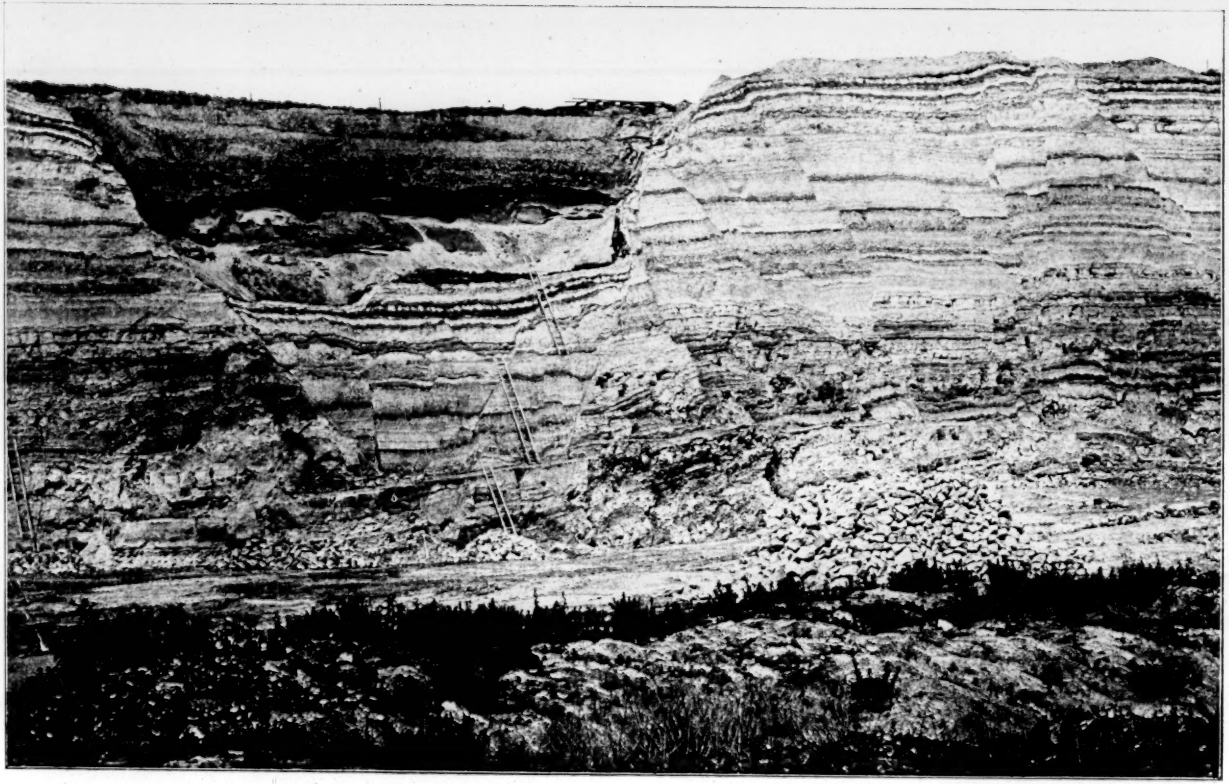
Dalmanites, sens. str. (= *Hausmannia*) was almost solely a northern form during the Silurian period, but during the Devonian period extended also into the south.

The various subgenera of *Dalmanites* in Devonian times were principally developed in North America, but some are found in central and southern and more rarely in northern Europe.

Stratigraphical Distribution.

Stratigraphically the whole of the genus *Pterygometopus* is confined to the Ordovician, and it accomplished its whole range of modifications within the limits of that period.

Dalmanitina is also typically an Ordovician group. *Dalmanites*, sens. str., though principally Silurian, ranged up into the Devonian. *Phacopidella* is Silurian, and the typical *Phacops*, sens. str., appears in the Silurian but reaches its maximum in the Devonian. The whole family became extinct before the dawn of the Carboniferous.



SECTION NEAR WIESBADEN.

Showing good examples of faulting in Mosbach Sands and Gravels, of Glacial age, which have been let down between two faults to pictures into the underlying marls of Miocene age with *Hydrobia*, etc., of the Mayence basin.

NOTICES OF MEMOIRS, ETC.

I.—Geological Observations in the District of the Ancient Channels by which the Main and Neckar flowed into the Rhine near Wiesbaden.

"Geologische Beobachtungen im Gebiet der alten Mündungen von Main und Neckar in den Rhein." Von A. Steuer.

(PLATE XI.)

THE accompanying photographic plate gives a good example of faulting in the Rhine Valley near Wiesbaden in the Pleistocene period. The section in a large quarry south-east of Wiesbaden, south of Mosbach, was photographed during a recent survey of the district by Herr Steuer, but other instances had long been known.

On the right-hand side are shown the Hydrobia deposits (Miocene) covered by a thin layer of old river terrace, the Mosbach Sands. The contrast between the hard calcareous beds and layers of marl with Hydrobia brings out the faulting very clearly. On the left-hand side a large 'wedge' of the sands is let down 10 metres into the underlying marls, bringing Pleistocene deposits sharply against Tertiary. Many small faults may be seen both inside the wedge and in other parts of the section.

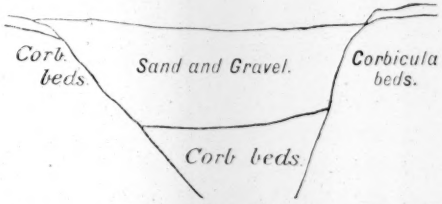


Diagram showing a large wedge of Mosbach Sands and Gravel of Glacial age, which have been let down, by faulting, 10 metres into the underlying marls of Miocene age with *Corbicula* and *Hydrobia* of the Mayence basin. (See centre of Plate XI.)

The Mosbach Sands have yielded *Ursus spelæus, Elephas primigenius, E. antiquus, Cervus canadensis, Alces latifrons, Rhinoceros Mercki, Bison priscus*, etc.

The old terraces of the Maine near its confluence with the Rhine are divided into three. The earliest, corresponding to the Mosbach Sands, is found at about 450 feet above the sea-level, or 200 feet above the present river. But subsequent earth-movements have displaced it to such an extent that it is occasionally seen 150 feet below its normal level. The next terrace is not found in the special district described by the author, but the third, and lowest, forms a narrow belt along the river side not very far above the present flood-levels.

The greatest earth-movements are believed to have taken place between the formation of the second and third terraces, but from the evidence given by the old channels in the youngest terrace it is

inferred that the movements were repeated after that epoch, and are perhaps not yet ended.

The oldest terrace is now regarded as Lower Diluvium, the others belonging to the two divisions of the Middle Diluvium. This classification differs somewhat from that published by Dr. Kinkelin, and makes the terraces contemporaneous with older stages of the Alpine Glacial Series. T. I. Pocock.

II.—Report on Thorianite and Thorite. By Ananda K. Coomáraswámy, B.Sc., Director, Mineralogical Survey, Ceylon.

THIS report gives more precise details than have hitherto appeared of the locality and associations of the new mineral thorianite. This mineral, it will be remembered, was shown to be a new species by the analysis of Mr. G. S. Blake, of the Imperial Institute, who found that it contained as much as 76 per cent. of thoria and only about 12 per cent. of oxide of uranium, and thus differed materially from pitchblende, to which it had been at first referred. As shown on a map, which accompanies the report, the principal deposits of thorianite occur in and near the bed of the Kuda Pandi-oya, a small stream near Kondurugala, Bambarabotuwa, Province of Sabaragamuwa, Ceylon. The mineral occurs in the bed of the stream in black cubic crystals associated with zircon and ilmenite. In this neighbourhood it has not yet been discovered *in situ*, but a few crystals have been found in a pegmatite vein on Ambalawa Estate, Gampola.

Mr. Coomáraswámy discusses the prospect of further discoveries, and we wish him success in his efforts in search of these deposits of minerals rich in thoria, now so valuable as the chief constituent of incandescent gas mantles.

REVIEWS.

I.—The Face of the Earth. By Eduard Suess, Professor of Geology in the University of Vienna. Translated by Hertha B. C. Sollas, Ph.D., of Newnham College; under the direction of Professor W. J. Sollas, LL.D., F.R.S., etc. Vol. I. 8vo; pp. xii, 604, with 4 maps, 2 plates, and 48 other illustrations. (Oxford: at the Clarendon Press, 1904. Price 25*s.* net.)

AFTER a period of more than twenty years the first volume of the famous and now classic work of Professor Suess, "Das Antlitz der Erde" (1883–85), has been made intelligible to every British geologist. The work meanwhile, by its broad and luminous teachings, has inspired many a distinguished geologist at home and abroad on all subjects connected with the surface-structure of the earth, and has largely increased our knowledge of the origin of the physical features in which both geologists and geographers are interested.

In the preface which the author has specially written for this translation he points out naturally enough "that the reader will meet, here and there, in the first two volumes, with a description

already antiquated." Here the translator and editor might well have assisted the student by inserting, in square brackets, references to the more important works that supplement and in some instances correct former views. To British readers this want is specially noticeable in the accounts of the volcanic phenomena of the Inner Hebrides (pp. 155–157) and in the references to South African geology.

Another serious omission is that of an index. With the probability of three other volumes, and the possibility only of "a fifth volume, consisting of index and geological maps," many years must elapse before this first volume will be as useful as it might and ought to be for reference. In other respects we have nothing but praise for the care and pains bestowed on the translation by Miss Hertha Sollas, and for the undoubted success with which, aided by her father, Professor Sollas, she has so clearly and faithfully expressed in English the ofttimes difficult language of the original.

The work contains in the introduction a sketch of the shapes of the continents and oceans, together with remarks on great earth-movements, on stratigraphical formations, and on the distribution of life. The main portion of the volume is divided into two parts. The first treats of the movements in the outer crust of the earth. The Deluge is discussed as the greatest natural phenomenon of which we have record. Delta deposits, earthquakes and volcanoes, and the relations which may exist between the sensible movements of the earth and the phenomena of dislocation, all receive notice.

In the second part accounts are given of the structure and history of a number of mountain chains—the Carpathians and the Alps, the mountains of India and other parts of Asia, and those of America. The basins of the Adriatic and the Mediterranean, the great deserts, and other prominent features are dealt with. In short, a general account is given of the structure of the earth's surface, and the description of the continental masses is followed by a detailed exposition of the difference which exists between the Pacific and Atlantic basins.

By using a slightly closer type the present work occupies 604 instead of 778 pages as in the original, but the print is clear and excellent in all respects, while the text-illustrations and the coloured maps are in no respect inferior, and in some cases much clearer, than in the original edition. It is a handsome volume, and is one which should find a welcome place in the library of every working geologist.

II.—*Cleiocrinus*. By Frank Springer. Mem. Mus. Comp. Zool. Harvard, vol. xxv, pp. 93–114, one plate. (Cambridge, U.S.A.; January, 1905.)

THE Ordovician genus *Cleiocrinus*, E. Billings, has always been a puzzle to those whom Mr. Springer calls 'Crinologists.' The structure of the stem and the lateral union of the arms have led recent writers to refer it provisionally to the Flexibilia Impinnata

or Ichthyocrinidæ (*sensu latiore*). The composition of the cup was unknown, but was seen to be peculiar; by careful dissection and preparation of specimens belonging to the Geological Survey of Canada, Mr. Springer has now been able to show that it consists of 5 infrabasals, 5 basals, and 5 radials, followed by a large series of fixed brachials and pinnulars, as well as by a vertical series of anals resting on the posterior basal. The peculiarity lies in the facts that the basal and radial circlets have been pushed down over the infrabasal circlet and top of the stem, and that in this process the radials have been separated, while the basals have been pushed up between them so as to support the first primibrachs on their shoulders. Mr. Springer also shows that the arms are pinnulate, a fact mentioned by Billings in obscure fashion but hitherto overlooked; and he states that the angles of both stem and lumen are interradial, instead of alternating as is the case in later crinoids. The conclusion of his most interesting research is "that *Cleiocrinus* is evidently an intermediate form between the Camerata and the Flexibilia," and in this respect he associates it with *Reteocrinus*. His precise intention, however, is not clear, and since he "looks for enlightenment" to phylogenists on this side of the Atlantic, a few suggestions may be welcome. The word "intermediate" can hardly be meant to imply either that the Camerata were evolved from the Flexibilia by way of *Cleiocrinus*, etc., or *vice versa*. The pinnulate stage of arm-structure found in *Cleiocrinus* was not approached by Flexibilia until the Carboniferous Epoch; on the other hand, the infrabasal circlet, in its complete retention of pentamerism, is more primitive than that of any known Flexibilia. Whatever be the origin of *Cleiocrinus*, we must therefore suppose that the Ichthyocrinoid character of direct lateral union of the arms has been independently acquired and no more proves a relationship to the Flexibilia than it does to the still more similar *Uintacrinus*. The composition of the cup and of the arms would allow us to place *Cleiocrinus* with the dicyclic Camerata or Inadunata; but pinnulation was not attained by any Inadunate crinoid before the Middle or Upper Silurian, while the lateral union of the arms is opposed to the general trend of Inadunate evolution. Therefore it seems most simple to place *Cleiocrinus* with the Dicyclic Camerata, from known representatives of which it differs in the suppression of interbrachials. On this ground it is necessary to erect for it a fourth family, Cleiocrinidæ, contemporaneous in its first appearance with Reteocrinidæ and Rhodocrinidæ, but, unlike them, producing no descendants. The structure of the base remains without precedent and, with our present knowledge, inexplicable; but it is hard to believe that the angular shape of the lower margins of the radials is reminiscent of their former position above the basals: is it not rather a downward prolongation such as we find in *Pentacrinus* (= *Extracrinus*)? The only approach to the structure in other respects is the familiar invagination of the base, as seen in the contemporary *Archæocrinus*, and the most probable hypothesis seems to be that the base of *Cleiocrinus* is an exaggeration of this type.

Mr. Springer is heartily to be congratulated on having elucidated this obscure form in his usual masterly manner, and on having thus posed fresh problems. The only fault to be found with the paper is that the area of the pages (36 × 28 cm.) is out of all proportion to their number. F. A. Bather.

III.—The Clays and Clay Industry of New Jersey. By Heinrich Ries and H. B. Kümmel, assisted by G. N. Knapp. Vol. VI of the Final Report of the State Geologist. Trenton, New Jersey, 1904. Royal 8vo; pp. xxvii, 548. Plates and maps, lvi; figures in text, 41.

IN this Report a very full and complete description of the various clay deposits in the State of New Jersey is given, and their origin, modes of occurrence, physical and chemical properties are discussed in considerable detail. It also contains a large amount of definite and practical information relating to the economic value and the various methods of manufacture suitable to the different kinds of clays, which makes it a reliable work of reference for all those engaged in this industry.

The clay deposits worked belong to various formations. In the northern part of the State there are extensive beds of late Glacial age apparently laid down in lake basins or estuaries by streams issuing from the margin of the great ice field which covered northern New Jersey. Cliffs of clay on the Atlantic coast and terraces bordering the river valleys, 30–50 feet above tide, are referred to the same period. The clay beds are frequently overlain by stratified sand and gravel, and in some places by glacial till. Of the clays of the Tertiary formation may be mentioned those near Bridgeton, which are regarded as of Upper Miocene or Pliocene age on the evidence of plant remains in the associated sandstones. The most important clay deposits in the State are of Lower Cretaceous age, and are known as the Raritan or Plastic Clay series. They are of considerable thickness, and they extend quite across the State from Perth Amboy to Trenton, and thence down the Delaware River. They were probably laid down in an estuary; the only fossils found in them are a few shells of brackish-water character. The beds vary from a white to steel-blue fireclay of considerable economic importance to black sandy clay used for ordinary bricks. A great drawback to working these clays is the thickness of the gravels and, in places, glacial drift, by which they are often capped. These Lower Cretaceous clays rest on beds of Triassic age.

Several excellent maps and numerous illustrations greatly add to the value of this Report.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 8th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "Observations on some of the Loxonematidæ, with Descriptions

of two New Species." By Miss Jane Donald. (Communicated by Professor Theodore Groom, M.A., D.Sc., F.G.S.)

Shells having more convex whorls, or less sigmoidal lines of growth than *L. sinuosum*, cannot be left within the genus *Loxonema*. The two new species described resemble the type in form and in the sinuosity of the lines of growth; but the whorls are ornamented with spiral striæ, two of which frequently stand out and give the shell a banded appearance. Both species are of Silurian age: one was obtained from the Aymestry Limestone near Ledbury, and from beds of about the same age at Llangadock; and the other from the Wenlock Limestone, Dudley.

2. "On some Gasteropoda from the Silurian Rocks of Llangadock (Caermarthenshire)." By Miss Jane Donald. (Communicated by Professor Theodore Groom, M.A., D.Sc., F.G.S.)

These fossils occur almost entirely in the state of casts and moulds. Eleven distinct forms have been made out, referable to some genera; but only seven are sufficiently well preserved for specific determination. Five of these are new, including one described in the previous communication; a new genus is described, for the reception of *Euomphalus funatus*. The first species described comes nearest to examples placed in the genus *Plethospira*, as represented by *Pl. Semele*, with which it might be placed in a new subgenus. Three other species, including two new ones, resemble shells referred to *Bemboscia*. The three species are turriculated, and the band is situated on the angle of the whorls, a little distance above the suture. The specimens described come from the horizons of the Upper Llandovery, the Wenlock, the Lower Ludlow (including the Aymestry Limestone), and the Upper Ludlow.

II.—March 22nd, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "An Experiment in Mountain-building: Part II." By the Right Hon. the Lord Avebury, P.C., F.R.S., P.S.A., F.G.S.

In this paper some experiments are described which were conducted by an apparatus by means of which pressures could be applied in two directions at right angles to one another, a space of 2 feet square being reduced to one 22 inches square. In the first series, plastic materials such as cloth and thin oilcloth were used, with layers of sand between them. Two main folds crossing at right angles were formed, the upper one shifted over the lower. The use of two layers of linoleum produced a different type of folding, and the lower layers of the linoleum were broken along the principal ridges. In the second series a layer of plaster was introduced; this was found to be fractured, tilted up into a 'writing-desk' form, and forced irregularly into the sandy layers. Overthrusts were thus produced, so that in some cases a boring would have passed through two or even four layers of the rigid substance. In other cases the edges of the primary fracture broke off more or less regularly, and the detached pieces were pushed up, assuming

gradually a very steep angle. The remainder of the edges of the plate of plaster, having now room, were able to approach each other. Pliable material above the plaster was thrown into one or a few extensive folds, while that beneath assumed a greater number of small folds.

2. "The Rhætic Rocks of Monmouthshire." By Linsdall Richardson, F.G.S.

The Rhætic rocks occur only in the neighbourhood of Newport; and the present paper describes three new sections and four new exposures. They are the following: Goldcliff, Bishton, Llanmartin, Llanwern, Milton, Bishpool, and Lis-Werry. Measured sections are given at each locality, that at Goldcliff being especially full in the middle portion of the series, because when visited by the author it was exposed in consequence of a breach in the sea-wall. The plane of separation between the 'Tea-green Marls' (Keuper) and the Black Shales of the Rhætic is very definite, and is not infrequently accompanied by an inch or two of conglomerate. The Rhætic ocean appears to have spread with comparative rapidity over the flats of the 'Tea-green Marl' in this neighbourhood. The most complete sequence from Keuper to Rhætic is around Cardiff, where the 'Sully Beds' (Etheridge's 'Grey Marls': not the 'Tea-green Marls,' which belong to the Keuper) constitute transition-beds formed where deposition proceeded continuously. Farther north the 'Black Shales' overstep on to lower and lower portions of the 'Tea-green Marls.' A non-sequence appears to occur at the base of the Paper Shales at Goldcliff, where the upper surface of the Cotham Marble equivalent is conspicuously water-worn.

III.—April 5th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Divisions and Correlation of the Upper Portion of the Coal-measures, with special reference to their Development in the Midland Counties of England." By Robert Kidston, F.R.S. L. & E., F.G.S.

The following classification of the Coal-measures is proposed by the author:—

Proposed Names.		*Names previously used.*
4. Radstockian Series	=	Upper Coal-measures.
3. Staffordian Series	=	Transition Series.
2. Westphalian Series	=	Middle Coal-measures.
1. Lanarkian Series	=	Lower Coal-measures (including the Millstone Grit).

The Staffordian Series includes the Blackband Group, beginning with the Bassey Mine Ironstone, the Etruria Marl Group, nearly barren of plant-remains, and the Newcastle-under-Lyme Group. The Radstockian Series includes the Keele Group and various beds in the Midland Coalfields hitherto referred to the Permian System. A classified table is given of all the plants known from the two upper series in the Potteries Coalfield, and a list of those observed in the Newstead boring, Trentham. The plant-yielding beds in

the shaft of the Hamstead Colliery, near Birmingham, between the depths of 243 and 411 yards from the surface, are undoubtedly referable to the Radstockian Series and to the Keele Group of the Potteries Coalfield; and the beds without plants, from 209 yards downward, belong to the same group. A bed at 440 yards is referable to the Newcastle Group. A list of these plants is given. These two series are recognizable in Denbighshire; and the Ruabon Marls of the Staffordian Series are as barren in plant-remains as the corresponding Etruria Marls. A list is also given from red and purple shales in Cumberland, which contain Upper Coal-measure plants. Part of the Ardwick Series of Manchester belongs to the Staffordian Series. A table of all plants known from the two upper series (3 and 4) is next given, the distribution of species in the four subdivisions is analysed, and the differences between the two series are discussed. Finally, a list of plants from the Bradford Colliery, Manchester, from shales extending from 8 to 107 yards above the "Bradford Four-Foot Coal," is appended, and the beds are placed in the Staffordian Series; while the species from shale immediately below this coal and from shale 88 yards lower down are classed with the Westphalian Series.

2. "On the Age and Relations of the Phosphatic Chalk of Taplow." By Harold J. Osborne White, F.G.S., and Llewellyn Treacher, F.G.S.

The paper opens with an account of the work hitherto accomplished in the Phosphatic Chalk of Taplow, and especially of the work of Mr. Strahan. The rocks at this locality are then described in detail, and the following classification is adopted:—

		Feet.
E. Upper White Chalk	(visible)	16
D. Upper Brown Chalk, or rich phosphatic band	about	8
C. Middle White Chalk	,,	16
B. Lower Brown Chalk, or rich phosphatic band	,,	4
A. Lower White Chalk	(visible)	17

The Lower White Chalk includes a thin layer of tabular flint and one of elongated nodular flints, and the first signs of phosphatic material were observed a few inches below the tabular seam. Attention is drawn to the presence of phosphatic nodules and concretions at certain horizons. Fossil lists are given from each of the above divisions; and the authors conclude that the Lower White Chalk belongs to the zone of *Micraster cor-anguinum*, and the succeeding beds to that of *Marsupites testudinarius*; while the lower phosphate-band represents the lower part of the *Uintacrinus*-band, and the upper one that of the *Marsupites*-band of that zone. In each phosphate-band the base is quite sharp, being defined by a rock-bed in the Chalk; but the upper limit is very ill-marked. The Middle White Chalk is in part divided into lenticles with slickensided surfaces. The authors find *Actinocamax verus* in B, and *A. granulatus* in D and E, but not *A. quadratus* in any bed. Phosphatization is not confined to the Foraminifera and other microscopic remains, but occurs in all shells and structures which are readily penetrable,

although not so markedly in those of a more homogeneous character. *Scalaria* occurs in division E, the upper part of which may possibly just include the base of the zone of *Actinocamax quadratus*, or at any rate may not be many feet below that base. The distribution, numerical proportion, and, to some extent also, the morphological character of the macroscopic fossils of the Phosphatic Chalk are exceptional. The majority of the French deposits of Senonian age appear to belong to a distinctly higher horizon. The authors give evidence to show that a part, at least, of the phosphatized material has acquired its distinctive mineralogical character on the spot. So far as can be ascertained from existing data, the Phosphatic Chalk is confined to a small tract of country measuring less than $3\frac{1}{2}$ miles from north-east to south-west by less than 1 mile from north-west to south-east. It occurs as an intercalation between the normal Chalk and the Lower Eocene (Reading) Beds, and occupies a structural trough which coincides with, and is probably due to, a synclinal flexure.

Mineralogical Society, March 15th, 1905. Professor H. A. Miers, F.R.S., President, in the chair. — Description of the big diamond recently found at the Premier Mine, Transvaal: by Dr. F. H. Hatch and Dr. G. S. Corstorphine. The stone weighed over $1\frac{1}{4}$ lbs., and its greatest linear dimension was 4 inches. It was part (probably less than half) of a distorted octahedral crystal.—On some new mineral localities in Cornwall and Devon: by A. E. I. M. Russell. An account was given of various new finds of the minerals anatase, scheelite, wolframite, childrenite, apatite, and connellite.—On a crystal of phenakite from Africa: by L. J. Spencer. This crystal, which was transparent and rich in faces, was brought back together with crystals of tourmaline, corundum, and amethyst, by the Rev. A. North Wood from the Usagara Country in German East Africa.—Notes on various minerals from the Binnenthal, Switzerland: by G. T. Prior and G. F. Herbert Smith. Further crystallographic and chemical details were given of the three new red minerals from the Binnenthal, originally described by R. H. Solly, and named by him Smithite (after G. F. Herbert Smith), Hutchinsonite (after A. Hutchinson), and Trechmannite (after C. O. Trechmann). Smithite is a sulpharsenite of silver, having the composition represented by the formula $AgAsS_2$; it is monoclinic with $a : b : c = 2{\cdot}2205 : 1 : 1{\cdot}9570$, β 78° 40′. A perfect cleavage parallel to 100 distinguishes it from the other two red minerals. Hutchinsonite is rhombic with $a : b : c = 1{\cdot}6356 : 1 : 0{\cdot}7540$. A prominent form is 140. Trechmannite is rhombohedral with $c = 0{\cdot}7265$. The symmetry is the same as that of quartz.—On a new oxychloride of copper from Sierra Gorda, Chili: by G. T. Prior and G. F. Herbert Smith. This new mineral, to which the name Paratacamite was given, has the same chemical composition as atacamite, but begins to lose its water at a higher temperature than that mineral. It is pseudorhombohedral with $rr' = 83°$ nearly. Twins about r are common. It displays optical anomalies, for minute fragments under

the microscope are found to be biaxial.—On Dundasite from North Wales: by G. T. Prior. The mineral was found by Mr. H. F. Collins in the Welsh Foxdale mine, Trefriw, Carnarvonshire; it occurs in white silky radiating tufts on cerussite with allophane; analysis showed it to be identical with dundasite, hitherto known only from Dundas, Tasmania. A probable formula is $PbO . Al_2O_3 . 2CO_2 . 4H_2O$ or $PbH_2(CO_3)_2 . Al_2 . OH_6$.

CORRESPONDENCE.

GRAPTOLITE ZONES IN THE ARENIG ROCKS OF WALES.

SIR:—It has been brought to my notice that in my paper on "Graptolite Zones in the Arenig Rocks of Wales," I have omitted a reference to a paper by the late Mr. T. Roberts, which was published in 1893, Quart. Journ. Geol. Soc., p. 166. I hope I made it clear that I fully recognised the value of Mr. Roberts' work, but I regret the unintentional oversight.

GERTRUDE L. ELLES.

SEDGWICK MUSEUM, CAMBRIDGE.

LOWER GREENSAND FORAMINIFERA FROM LITTLE COXWELL, NEAR FARINGDON.

SIR,—A book entitled "The Neocomien Sponges, Bryozoa, Foraminifera, and other fossils of the Sponge-gravel Beds of Little Coxwell, near Faringdon," by E. C. Davey, has just been published. It gives much new and interesting information regarding the fossils of the deposit. It was only of recent years, however, that the author became aware of Foraminifera occurring in the gravels; the credit of this discovery, he tells us, is solely due to Mr. F. Mockler, of the Holburn Museum, Bath. The Foraminifera were sent to me to be named. They consisted of a large number of specimens belonging to 53 different species, some of them being rare and interesting forms, and all or nearly all of them being now recorded from the place for the first time. It is, however, to be regretted that the proof was not sent to me for correction; the list is valuable, but as it is now printed contains a number of errors as regards the Foraminifera, and as it would be most desirable that it should be accurately given to be of use to others, I would be much obliged if you would kindly publish in the GEOLOGICAL MAGAZINE the corrected list which I now enclose.

FORAMINIFERA.

c. = common. v.c. = very common. r. = rare. v.r. = very rare.

Cornuspira cretacea, Rss. v.r.
Placopsilina cenomana, d'Orb. Specimens large. Frequent.
Haplostiche Soldanii (J. & P.). v.r.
Thuramminopsis canaliculata, Haensler. v.r.
Cyclammina cancellata, Brady. c.
Ammodiscus gordialis, J. & P. v.r.
Gaudryina oxycona, Rss. v.c.
Bulimina pupoides, d'Orb. v.r.
Bolivina tegulata, Rss. One specimen.
Lagena globosa (Montagu). v.r.
Nodosaria (Gl.) æqualis, Rss. v.r.
N. calomorpha, Rss. One specimen.

Nodosaria (*D.*) *pauperata*, d'Orb. Specimens not typical. v.r.
N. (*D.*) *consobrina*, d'Orb. r.
N. farcimen (Sold.). v.r.
N. (*D.*) *communis*, d'Orb. r.
N. (*D.*) *Roemeri*, Neug. v.r.
N. (*D.*) *mucronata*, Neug. v.r.
N. comata (Batsch). Slender form. v.r.
N. raphanus (Linné). v.r.
Lingulina carinata, d'Orb. Variety with segments slightly compressed. v.r.
Rhabdogonium tricarinatum (d'Orb.). Broken specimens. r.
R. Badensis (Hantk.). c.
R. globuliferum, Rss. v.r.
Marginulina Wetherellii, Jones. v.r.
Vaginulina legumen (Linné). r.
V. linearis (Montagu). One specimen.
V. arguta, Rss. r.
V. harpa, Roem. c.
V. striata, d'Orb. r.
V. marginuloides, Rss. One specimen.
V. recta, Rss. v.r.
Cristellaria rotulata (Montf.). v.c.
C. gibba, d'Orb. c.
Cristellaria crepidula (F. & M.). c.
C. lata (Cornuel). One specimen.
C. ensis (Rss.). r.
C. Italica (Defr.). v.r.
C. Schloenbachi, Rss. v.r.
C. acutauricularis (F. &. M.). v.r.
C. sulcifera, Rss. r.
C. subalata, Rss. r.
Flabellina rugosa, d'Orb. Some of the specimens are very fine. c.
Polymorphina communis, d'Orb. One specimen.
P. lanceolata, Rss. Specimens in poor condition. r.
P. soraria, Rss. One fistulose form.
P. regina, B., P., & J. One broken specimen.
Ramulina globulifera, Bradv. c.
Vitrowebbina irregularis (d'Orb.). v.r.
Spirillina margaritifera, Will. v.c.
Patellina corrugata, Will. c.
Discorbina orbicularis (Terq.). Specimens intermediate between *D. orbicularis* and *D. globularis*. c.
Rotalia orbicularis, d'Orb. One specimen.

JOSEPH WRIGHT.

4, ALFRED STREET, BELFAST.
April 11th, 1905.

THE FORMATION OF CIRQUES.

SIR,—Will you kindly give me a little space in which to correct a mistake I have made on p. 437 of vol. i of my new book, in which I have done a double injustice, one to my friend Professor Bonney and the other to myself.

In discussing the theory of the ice excavation of cirques I mention him as a champion of the notion, whereas, as is perfectly plain from his writings, he opposes that theory, so that he is on my side entirely instead of against me on this point.

The fact is the reference to Professor Bonney ought to have been inserted in an earlier chapter and in reference to the aqueous erosion of cirques, a view he does endorse, while I feel obliged to side with Falsan and the other French geologists who have studied the great cirques of the Pyrenees and attribute them to deformations and otherwise original structural features imposed on the upper Alpine and other valleys at the time the contour of the mountain ranges was first given to them. As it is my practice always to correct my errors when they have been pointed out, I take the first opportunity of putting this small slip right, and it is particularly pleasant to me since I gain a powerful friend to my side of the argument by doing so.

HENRY H. HOWORTH.

30, COLLINGHAM PLACE,
CROMWELL ROAD, S.W.
April 17th, 1905.